Dispositional Essentialism and Ontic Structural Realism - a hybrid view

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Abstract

Dispositional Essentialism and Ontic Structural Realism aim to account for modality. Dispositional Essentialism takes properties to account for laws. In particular, it takes determinate properties to account for laws of nature (Bird, 2007), which are determinable. Ontic Structural Realism does the reverse. According to Steven French, Ontic Structural Realism takes laws and symmetries to be part of the fundamental structure of the world. Determinate properties are "dependent" on laws (2014, p. 264).

The core difference between Dispositional Essentialism and Ontic Structural Realism's accounts of modality is the direction of the dependence between properties and laws. As a result, French describes Ontic Structural Realism as a reverse-engineering of Dispositional Essentialism (2014, p. 264), and Chakravartty differentiates them by saying that Dispositional Essentialism gives a bottom-up account of modality whereas Ontic Structural Realism's is top-down (2019). Both views face significant problems.

The main problems these views face stem from relational individuation. Properties are individuated by their relations to further properties. As such, it is hard to see how they can be metaphysically prior to those relations as per Dispositional Essentialism. Equally, laws are relations between properties. As such, it is hard to see how they could be metaphysically prior to the properties they relate as per Ontic Structural Realism. Both properties and laws seem dependent on each other. By requiring one to come first and explain the other, dispositional essentialists and ontic structural realists end up in a chicken-egg scenario.

I propose a hybrid between Dispositional Essentialism and Ontic Structural Realism. My hybrid view does away with the dogma of ontological priority between properties and laws. Instead, properties and laws symmetrically depend. I argue that my hybrid view is the way out of the chicken-egg-property-law conundrum. It paves a new way for making sense of modality from a structuralist perspective.

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Contents

1. Introduction

The evidence of nature's lawfulness is everywhere. Even the smallest human task relies on an intricate web of laws, like gravitation, which we consciously or unconsciously rely on. There is a predictable order to our world.[1] How we explain this predictability is another matter.

There are philosophers who see laws as brute or accidental regularities, others who see them as immutable and necessary and, of course, there is everything in between. I will be particularly interested in theories that take properties and laws to be metaphysically linked. In particular, I will examine Dispositional Essentialism, which takes properties to explain laws, and Ontic Structural Realism, which according to Steven French does the reverse (2014, p. 264). In other words, Ontic Structural Realism takes properties to depend on laws. I will look at these with the aim of forwarding a novel view – a hybrid between the two. My view will take properties and laws to be symmetrically dependent so that they explain each other. I argue that this avoids many of the pitfalls of Dispositional Essentialism and Ontic Structural Realism while providing a more coherent account of the relationship between properties and laws.

Talk of properties and laws often come together. I like to use the example of the property of charge and the respective law (Coulomb's law). Coulomb's law tells us how charged objects interact. It explains why like charges repel each other whereas opposite charges attract. In much of the property and law discourse, what properties do (what laws they follow) has been separate from what properties are.

In chapter 2, I survey the most popular views on properties and their relation to laws. I start with Categoricalism. Broadly, Categoricalism is the view that properties have some sort of intrinsic identity. Intrinsic here can be understood in opposition to modal. A property's modality refers to what that property does, what laws it follows and how it manifests in the world. For categoricalists this is separate from what the property is. As we shall see, identifying properties intrinsically rather than by their modality leads to

[1] It is worth noting that John Dupré (1995) argues that there is also much disorder to the world and in science. However, his arguments and examples mainly stem from the special sciences, particularly biology. I will not debate the status of laws across these sciences here. My main focus will be on fundamental physics.

interesting consequences. For instance, it opens the possibility that properties like charge and mass could have had different roles, maybe even swapped roles entirely.

One of the two key players in this thesis, Dispositional Essentialism, arose in opposition to Categoricalism. Broadly, Dispositional Essentialism is the view that at least some properties have dispositional essences. In other words, they get their essence and identity from their modal links to further properties. Dispositional Essentialism promises to account for all modality from the nature of properties. Dispositional properties give rise to laws of nature. Back to our example, the nature of charge is responsible for the existence of Coulomb's law. Any world with a charged object will be a world where Coulomb's law applies.

In chapter 2 we see that Dispositional Essentialism has great appeal. It explains the lawfulness of nature via the nature of properties, an ingredient most philosophers carry in their ontology. However, few philosophers have appreciated that this view still faces some problems accounting for laws of nature:

A) the properties dispositional essentialists are realists about are often determinate whereas some laws of nature are determinable
B) laws are more complex than some dispositional essentialists allow
C) certain laws – global principles – seem to apply to everything in existence not just a specific property

The first problem will be the main topic of chapter 3 which starts by laying out what determinates and determinables are. Very briefly, a determinable is a broad property that encompasses determinates. So, for instance, "scarlet", "maroon" and "crimson" are determinates of the determinable "red". At the same time, "red", "blue" and "yellow" are determinates relative to the determinable "colour". The issue is that the properties dispositional essentialists are realists about are typically specific instantiations of properties in our world e.g. the charge of an electron, the mass of my phone, the maroon of this coat. These are maximally determinate. Alexander Bird (2007) goes as far as to say that dispositional properties are single-track so that they have one stimulus and one manifestation possibility. The problem is that many laws of nature are not determinate. Coulomb's law would not be very informative if it could only tell us how an object with a specific magnitude of charge will manifest. Rather, many laws of nature are

determinable or functional. They tell us how a range of properties under broad determinables interact. That is what makes them so impressive.

Chapter 3 focuses on how we get from properties to laws within Dispositional Essentialism, answering A) and B). In particular, I will endorse realism about the determinable properties, seeing these as what explains the determinable laws of nature. Following Jessica Wilson (2012), I will argue there is need for both determinates and determinables in our ontology. Determinates provide 'existential witness', or tell us what is instantiated in our world. Determinables provide us with the modal information, they ground laws of nature. I will look at the arguments against realism about determinables but will show that they do not apply or are overruled by determinables having a unique explanatory role to fill. Additionally, following Vetter (2012, 2015) I will argue that we need to be a bit more flexible than the likes of Bird with regard to laws. Bird suggests laws codify a single manifestation and stimulus relation. However, laws come in all shapes and sizes, relating different numbers of variables and constants.

In chapter 4 I tackle what I see as the biggest problem for Dispositional Essentialism – accounting for global principles. Global principles are laws that appear too broad to be accounted for from the bottom-up, based on the dispositional essence of a single property. Global principles are often not seen at the local level, where a property is instantiated. They require taking a step back and looking at the bigger picture. Examples include: the principle of least action, symmetry laws and conservation principles. It is not merely a particular object that conserves mass-energy, rather it is in all objects and interactions that we see this conservation.

Dispositional essentialists have not done much to address the problem of global principles. In 1992, they forwarded the world-kind explanation of these laws (Bigelow, Ellis and Lierse). According to this hypothesis, the world is a member of the world-kind and, as a member of this kind, it has certain (dispositional) properties which give rise to laws of nature. This suggestion seems *ad hoc* and has taken a toll on the credibility of Dispositional Essentialism (Livanios, 2010; Smart and Thébault, 2015, p. 390). However, there are more modern ways of approaching the issue.

Anjan Chakravartty (2019) forwarded what I see as a more modern version of the world-kind hypothesis. He argued that we have good evidence from science that certain systems have properties e.g. cells, organs, entangled systems, etc. This could help with

global principles. Say physically closed systems have properties. The universe is the only physically closed system in existence so it could have properties in virtue of its causal closure. If these properties are dispositional, they would give rise to laws. These laws would be global, universe-level, laws.

I forward a third and novel possibility. I see it as a more minimal and palatable adaptation of Chakravartty's view. Chakravartty makes a good case for systems having properties. I accept that there is excellent evidence for high-level properties but I argue that there is no need for high-level entities to accompany them. We can explain global principles via high-level properties without postulating an *ad hoc* universe-wide property bearer. I argue for collective properties. In other words, I argue that things can come together and jointly or collectively bear a property. For instance, two electrons can have a joint spin. We don't need two electrons and a third object which is the system of the two electrons. The two suffice if we see the property as collectively borne by them.

In chapter 5 I look at case studies of global principles. In particular, I look at conservation laws and the principle of least action. I look at why the kind of account Dispositional Essentialism gives of regular laws fails here. Further, I look at the various ways we can account for these laws within Dispositional Essentialism. My hybrid view does not hang on any specific approach to global principles. However, I argue that Chakravartty's view and my view are preferable for a number of reasons. Chakravartty's view seems like a clear improvement on the world-kind view. My view provides a new, unexplored, way of making sense of global principles without postulating questionable high-level entities at all. Until now global principles have not been thoroughly explored within Dispositional Essentialism. They are usually avoided or used to mock the view. I hope to breathe new life into the debate, showcasing new views which are less ontologically loaded. I show that these principles are not insurmountable for Dispositional Essentialism. Further I will show that, despite claims to the contrary, global principles are no more a problem for Dispositional Essentialism than for the view we look at next – Ontic Structural Realism.

In chapter 6 I move onto the second main player in this thesis – Ontic Structural Realism. I start by looking at the historical context for this view. Structural Realism started as an epistemic view, about what we know. Epistemic Structural Realism is the view that all we *know* is structure. Briefly, the idea is that we can only know objects and properties via their structure and how it manifests in the world. Prod as we may, we

cannot know a thing's intrinsic or categorical nature. Ontic Structural Realism takes this up a level. It says that *all there is* is structure. There is nothing more to reality. Ontic Structural Realism is a controversial view. This is partially because what structure is is a matter of controversy, ranging from mathematical or abstract structure to modal structure in more moderate iterations. I discuss a few versions of it, but even at its most moderate, it requires radical revisions to our view of objects. Traditionally, we think of objects as existing independently of their relations to further things, however, on this view they are reduced to their structural components. They are at most nodes in the structural web of reality. That said, as we shall see, there are many good scientific and metaphysical arguments for this view.

Generally Dispositional Essentialism and Ontic Structuralism have kept very different company. Dispositional Essentialism has been discussed in the property literature in traditional metaphysics, as an alternative to Categoricalism. Ontic Structural Realism has been discussed in the philosophy of science literature, often alongside quantum concerns. However, recently a growing number of philosophers have pointed out that these two views are much closer than they may seem (Esfeld, 2004, 2009; Esfeld and Lam, 2011; French 2014; Chakravartty, 2019). These philosophers have tried to pin down and explain the ontology of Ontic Structural Realism. In the process, it becomes clear that the underlying ontology of this view is reasonably close to that of Dispositional Essentialism. I will look at the work of these philosophers as it sets the scene for my own hybrid view.

Steven French claims that Dispositional Essentialism and Ontic Structuralism are so close that they are a reverse engineering of each other (2014). Both views share a common goal to account for modality. Further, they have similar starting materials – properties and laws. However, they differ in a very important way. Dispositional Essentialism takes properties to be fundamental, and to account for laws. According to French – who is as representative a spokesperson of Ontic Structural Realism as any – Ontic Structural Realism does the reverse. It takes laws to be part of the fundamental fabric of the universe, properties are dependent on laws. This leads Chakravartty to claim that the difference between these two views is the direction of the property-law explanation (2019). Dispositional Essentialism gives a bottom-up account of modality (from properties to laws), Ontic Structural Realism does the reverse. It gives a top-down account (from laws to properties).

In chapter 7 I forward my own hybrid view. Where Dispositional Essentialism gives a bottom-up and Ontic Structural Realism gives a top-down account of reality, my account is level. Properties and laws are equifundamental and symmetrically dependent. I argue that this view makes the most sense of the relationship between properties and laws. It is worth clarifying that my view is only a hybrid between Dispositional Essentialism and Ontic Structuralism's views on modality and the relationship between properties and laws specifically. Dispositional Essentialism and Ontic Structural Realism have very different approaches to other issues, like objects. Famously, Ontic Structural Realism has a revolutionary and revisionary approach to objects, where Dispositional Essentialism tends to ruffle fewer feathers. My view will be neutral on such issues. My solution to the issue of accounting for modality from a structuralist/dispositionalist perspective will be compatible with the plethora of views on the status of objects.

Within Dispositional Essentialism, properties get their essence and identity from the relations they bear to further properties. Yet, the properties are supposed to ground the laws of nature. Laws of nature are relations between properties. If properties get their identity and essence from their relations, they cannot ground those relations. A thing cannot be essentiality and identity dependent on that which it grounds (Jaag, 2014). Ontic Structural Realism also raises eyebrows by putting laws first and seeing properties as dependent. If laws are relations between properties, how can they be metaphysically prior to properties? It is not clear how relations could unilaterally explain their relata.

Within dispositionalism/structuralism properties and laws are enmeshed in such a way that it is hard to see how one could explain the other. As David Yates (2018) put it, choosing whether to give properties or laws priority lands us in a chicken-egg scenario. I propose that we drop claims of ontological priority between properties and laws and let properties and laws symmetrically depend.

In order to argue for and flesh out my view, chapter 7 touches on many issues. A major theme will be ontological dependence, particularly symmetric dependence. I look at why philosophers have shied away from this sort of dependence. I argue that there are good reasons to allow for symmetric dependence, especially in this case. Another theme is exactly how I flesh out my ontology – what properties or laws I need in it. This takes us back to earlier chapters where I argued that we need determinable properties in our ontology to account for laws of nature.

Briefly, dispositional essentialists have traditionally discussed determinate properties and determinable laws in their theory. Ontic structural realists, at least according to French, have done the same. Very briefly, he follows Wilson (2012) in saying that we need determinables to account for modality as well as determinate properties to provide existential witness and explain the universe as we know it.

For my part, in chapter 3, I conceded to Wilson the need for determinable properties which ground determinable laws. Similarly, I will say that determinate properties contain the modality of determinate laws within them. So, my modal ontology will incorporate determinate properties, determinate laws, determinable properties and determinable laws. Naturally, another key theme will be the relationship between determinates and determinables.

Where Wilson and French talk about determinables as modal and determinates as 'existential witnesses', I think this can be a bit too quick. Determinate properties are also modal in a sense. After all, within Dispositionalism they get their identity and essence from their dispositions. In my view, they give us non-modal *information* about what is instantiated. However, that is not to say they are non-modal *per se*, they have a limited – determinate - modality. If we want the big picture modal facts, and to explain laws of nature, we need determinable properties. Their role is not threatened by allowing determinate properties a limited modality.

Determinates and determinables clearly have a special relationship. Determinates under the same determinable resemble each other in special ways – "red" resembles "blue" in a way that it cannot resemble "circle" or "square". Further, determinates of the same determinable are mutually exclusive and fix their determinables. Yet, to say that we can do away with determinables is premature. As we saw, determinables tell a broader modal story, and there is a sense in which they too constrain what determinates do. While I cannot settle the issue of the relationship between these two here, I show that neither can be given priority over the other. They are both needed to give the full picture of reality and to fully account for the evolution of our universe.

In chapter 8, I address some final lingering concerns that may arise in response to my view. In section 8.1, I look at the potential worry that my hybrid view will be a bad combination of the previous two views. The worry is that it would be subject to the problems of both views, so it would present the worst of both worlds. Both Dispositional

Essentialism and Ontic Structural Realism have unique selling points and shortcomings. I will be arguing that the hybrid view avoids the shortcomings of these views while retaining and superseding the best they have to offer. So, it is in fact the best of both worlds.

Finally, in section 8.2, I address the worry that my view is less parsimonious than Dispositional Essentialism, Ontic Structural Realism, and even a basic hybrid of the two. I argue that my hybrid view is worth the trade-off. It has a massive explanatory edge (it fully accounts for modality) for a very low price: accepting determinable properties and determinate laws into an ontology that already had determinables (laws) and determinate properties. However, the motivation for my view is deeper. Dispositional Essentialism and Ontic Structural Realism's ontologies have holes. These holes are left by relational individuation. Properties are relationally individuated yet the individuators of determinate properties are missing. Laws of nature are relations between properties yet the properties they relate (determinable properties) don't exist. This places the very coherence of these views into question. My hybrid view fills these holes, offering a coherent and thorough account of properties, laws and the relationship between them.

Having dealt with potential objections to my view, my case for the hybrid view is complete. Dispositional Essentialism gives a bottom-up account of reality. It takes properties to get their identity and existence from the relations they bear to further properties. At the same time, it expects properties to ground laws, which is problematic. Ontic Structural Realism gives a top-down account of reality. It takes laws to be fundamental and properties to need explaining. But if laws are relations between properties, it is not clear how can they be prior to the things they relate – the things which give them their identity and existence. In my view, if you are a structuralist you would do better to reject priority claims between properties and laws, allowing them to be equifundamental and mutually dependent. My hybrid view offers an escape from chicken-egg structuralism. My hybrid view offers the structuralist a positive account of modality that avoids the problems of previous views.

2. Laws in Dispositional Essentialism

Broadly, Dispositional Essentialism aims to ground natural modality in properties. Properties are dispositional. They are dispositions to certain manifestations given certain stimuli. These dispositions account for the lawfulness of nature. In this chapter, I will look at various criticisms of the dispositional essentialist project of accounting for laws via dispositions. I will start by giving some historic perspective on the nature of properties and laws via a discussion of Categoricalism. This view takes properties to have no essential modal character and laws to be contingent, allowing for worlds where properties change, swap, or invert nomic roles. I will show how Dispositional Essentialism arose in opposition to this view, with a promise of explaining modality via properties and allowing for necessary laws of nature. After I have done this, I will lay out the main criticisms of the dispositional essentialist account for laws, which I will respond to in the next chapters.

2.1 Categoricalism and laws of nature

Dispositional Essentialism is a relatively recent view. In the past, the debate about laws of nature aligned with a Categoricalist perspective. Here, by Categoricalism I mean the view that properties do not have essential modal features. They are not identified by what they do, or what laws they follow. These are contingent facts about properties. By contingent I mean that they could have been different or are different in other possible worlds.

There are two main views of laws within Categoricalism. The first, which is still popular today, is the regularity view of laws. This view was popularised by David Lewis, inspired by David Hume's influential work on causation. Hume says that we never see the necessary connection between events, we only witness a regular association of events (2007). This leads to what is known as the problem of induction whereby we have no proof of our inductive inferences. Famously, we have no proof that the sun will rise tomorrow. All we have are a bunch of observations of the sun rising, nothing more.

David Lewis was a strong advocate of Humean Supervenience – the view that "all there is to the world is a vast mosaic of local matters of particular fact, just one thing and then

another" (1986, p. ix). He described the universe as a system of points with spatio-temporal relations between them, with local properties. His view is called Humean Supervenience because he believes that all else, laws included, simply supervene on that mosaic. There are regularities which we observe but they could have been otherwise. Elizabeth Miller describes Lewis's view as a pointillist painting where any point could have been placed elsewhere (2014). We can infer laws from the overall harmony of the painting, but they supervene on the points rather than dictating their arrangement.

According to the regularity view laws are not independent ontological entities. In fact, they are not even fixed. Rather, our universe happens to display certain regularities. These regularities are brute, unexplained, and contingent. Laws of nature are simply higher order regularities, which track fundamental regularities and systematise where possible. We infer laws from regularities, but they could be broken at any point. The properties they relate are freely recombinable. This view is associated with the BSA – best system analysis – of laws. The BSA contends that there are many different possible laws we could use to explain the world around us. We ought to assent to those which feature in the best system account – the account with the best predictive power.

The second categoricalist view of laws is the DTA view, named after Fred Dretsky (1977), Michael Tooley (1977) and David Armstrong (1978) who expressed similar views around the same time. On this view, laws are relations between properties. Here properties are taken to be universals – abstract properties which individuals instantiate. In a way their view is almost a middle ground between the Lewisian view (which has contingent laws) and dispositionalist views (where laws are necessary). DTA take laws to be contingently necessitated.

When philosophers speak of things being necessary they usually refer to trans-world necessity. In other words, the necessary thing occurs in every single possible world. For instance, 2+2=4 is true in every possible world. Conversely, a thing being contingent means that it could have been otherwise. For instance, I could have got a cat rather than a dog. Thus, there are worlds where the thing occurs and worlds where it does not. It could have not been the case. As a result, the idea that laws are contingently necessitated can seem strange or paradoxical.

In the DTA, laws are relations between properties, for instance the universals Q and P. Those laws are thought to be *contingently* necessary because they could have been

otherwise. The contingent aspect comes from the fact that the relations between universals may be different in different worlds. This is a natural consequence of their Categoricalism about properties. As a categorical view, properties (universals) do not have intrinsic modal characteristics, as such their relations to other properties may be different in other worlds. So, in what sense are they necessary? The necessity here refers to the idea that, if two universals are connected in a world, the law is necessary within that world. So, every instance of Q relates to an instance of P, they cannot be separated in a world where the universals are connected in this lawlike fashion. Thus, when advocates of the DTA view say that laws are contingently *necessitated* they do not mean trans-world necessity. Instead, they mean to say that laws are intra-world necessary, they apply without exception within each world. Laws are fixed at worlds according to the relations between universals in that world.

The two major downsides of Categoricalism, which fuel Dispositional Essentialism (which we will turn to soon), are the fact that it implies quidditism and humility about properties (Esfeld, 2009). This creates a gap between properties and laws which makes laws accidental or contingent. Regarding quidditism, recall how properties are viewed within Categoricalism. They have no essential modal characteristics. Rather their essence is internal to them, and not given by their relations to anything else. As I said, Categoricalism is associated with quidditism, whereby properties are individuated by their quiddity or their intrinsic aspect or nature.[2] A property is what it is because of this quiddity. Humility refers to the fact that the real essence of properties is inaccessible to us.

David Lewis explains quidditism via the notion of Combinatorialism (2009, p. 208). In his view, properties can be freely combined and recombined. Two properties could swap roles without us noticing (more on this soon). However, there is something inherent in properties which means that the two scenarios would be distinct. This is the quiddity of the property – its intrinsic nature or intrinsic this-ness. Again, consider a world where we have swapped a property out for another, but no one can tell. These two worlds are still distinct. Their being distinct has nothing to do with whether we can tell them apart,

[2] Dustin Locke (2012) argues that there are forms of quidditism so austere that properties are individuated by their numerical identity. However, for the most part quidditism seems to refer to the view that properties have an intrinsic quality which individuates them.

epistemic considerations do not enter the picture. They are distinct because the properties are distinct.

The notion of Combinatorialism and Quidditism are closely tied to that of Humility to the point that Lewis says "Given Combinatorialism and quidditism, our argument for Humility is complete." (2009, p. 209) Within Categoricalism we cannot know the essence of properties via powers, or what they do, the essence of properties is hidden from us. We cannot know charge via our observations of charge, its behaviour is contingent and so our observations tell us nothing about its intrinsic nature. In fact, as we saw, properties can be swapped around (Combinatorialism) without us knowing. They are only differentiated via an intrinsic nature which is beyond our acquaintance (Quidditism). As a result, we are left in perpetual ignorance about the true nature of properties. This ignorance is what is referred to as humility. Humility highlights the fact that we can never know the character of the properties that populate our world. No amount of interaction with said properties will let us know what they are like or how they differ from any other property intrinsically.

The fact that the nomic roles of properties are non-essential and contingent leads to a gap between properties and laws. Laws vary from world to world and, as such, there is always a degree of contingency to them – they are not necessary. Combinatorialism within Categoricalism allows for counterintuitive inverted or I-worlds. These are worlds where properties behave slightly differently or even fully invert their nomic roles. So, for instance, mass and charge could swap roles. Charge could obey mass-laws and mass could obey charge-laws. In Lewis's words:

> "Suppose, for instance, that we start with the actual world, and we permute two fundamental monadic properties F_1 and F_2… Then F_2 will be found in exactly those places in space and time (or, more generally, in the pattern of the places where F_1 was found originally; and vice versa. And the laws of nature governing F_1 in the permutation will be just the same as the laws governing F_1 originally (more precisely, the laws governing F_2 vis-à-vis F_1 in the permutation will be the same as those governing F_1 vis-à-vis F_2 originally) and *vice versa*." (Lewis, 2009, p. 208)

For the dispositional essentialist I-worlds are unthinkable. A world where F_1 plays the role of F_2 and vice-versa, or where mass plays the role of charge and vice-versa is not

possible. This is a world where we have swapped the labels F_1 and F_2 and/or "mass" and "charge". This is because, for the dispositional essentialist, what a property does is essential to it.

2.2 Dispositional Essentialism and laws

Dispositional Essentialism arose in opposition to Categoricalism. It arose in opposition to the view that properties have no intrinsic modal characteristics, to contingent laws and I-world. Dispositional essentialists do not accept regularity views or contingent views of laws. Dispositional essentialists aim to ground all modality in dispositional properties.

It is worth noting that ontologies with dispositional properties and categorical properties are not necessarily mutually exclusive. Some dispositional essentialists (like Ellis, 2001) allow for categorical properties in their ontology. However, I set this aside as it has no impact on my argument. This is because I am concerned with how dispositional essentialists account for laws of nature. While the possibility of categorical properties is contentious within Dispositional Essentialism, the fact that dispositional properties ground laws is not. Alexander Bird (2007), Brian Ellis (2001) both claim that dispositions ground laws and Stephen Mumford (2004) says that dispositions are responsible for the lawfulness we see in nature despite not being a realist about laws *per se*.

Broadly, Dispositional Essentialism is the view that there are dispositional properties. Those properties account for laws of nature. As a view, it is quite liberal as it is compatible with many kinds of realism about properties. Most dispositional essentialists have traditional ontologies, viewing properties as universals. Some see those universals as immanent (Ellis, 2001; Mumford, 2004) meaning that the universals only exist when instantiated. Others see them as Platonic, meaning they exist regardless of instantiation (Bird, 2007 leans this way; Tugby, 2013). It is worth noting that Dispositional Essentialism can also make compatible with trope views of properties (Molnar, 2003), however I will not be delving into that view here.

When Dispositional Essentialists talk about properties, and how they give rise to laws, they generally mean to pick out fundamental or sparse properties. These will be the

dispositional properties that account for laws of nature. Sparse or fundamental properties are those which play an important role in our ontology and are needed in fundamental science. This notion is inherited from David Lewis. According to Lewis:

> Fundamental properties are… not at all disjunctive, or determinable, or negative. They render their instances perfectly similar in some respect. They are intrinsic; and all other intrinsic properties supervene on them." (Lewis, 2009, p. 204)

According to Lewis, fundamental properties cannot be disjunctive or determinable. I take Bird to have a similar view, on the basis that he claims that only single-track properties are fundamental. By single-track Bird means properties with a single stimulus and manifestation condition. We will look at this in detail later in this chapter as well as in the next chapter. For now, suffice to say that which properties are fundamental is debatable and this kind of Birdian-Lewisian view is on the narrow side. Further, and directly in contrast with Bird, we will see that there is a compelling case to be made for the view that dispositions may be inherently multi-track (Vetter, 2015) or determinable (Wilson, 2012).

The core of Dispositional Essentialism is that dispositional properties exist and are responsible for the lawfulness we witness in nature. This remains true regardless of your stance on controversial issues like which properties we ought to be realists about. These properties have no categorical basis or quiddity. When I say that properties have dispositional essences, I mean that properties are identified, and their nature exhausted by their nomic roles. These properties are inherently modal.

Generally, dispositional essentialists take the nature and identity of a property to be rooted in its disposition to manifestation M given stimulus S. For instance, for something to have the property of being fragile it must be able to break. Further, it must be quite susceptible to breakage. Of course, something could be fragile and never break provided that, if it were put under a certain amount of stress, it would break. On the standard approach, properties are identified by their stimulus-manifestation conditions (Bird, 2007, pp. 138-46). However, it is worth noting that there are other ways of characterising dispositions. Barbara Vetter argues that dispositions ought to be identified solely by their manifestations (2015, chapter 3) and Anna Marmodoro rejects the stimulus-manifestation view altogether, seeing the exchange between powers as

reciprocal (2017). I will not focus on how exactly to define or identify dispositions. In fact, my ultimate view will leave this sort of interpretation of dispositions open. However, I take the view that dispositions are dispositions to certain manifestations given certain stimulus as standard and as my starting point for exploring how Dispositional Essentialism can account for modality. In the process, I will show that it is oversimplified. The idea that we can codify dispositions (and laws of nature) into simple single-stimulus-single-manifestation conditions is too restrictive. Some departure from this strict model will be needed to account for laws of nature.

One of the greatest appeals of Dispositional Essentialism is that it avoids the troublesome I-worlds I spoke about earlier. To reiterate, Dispositional Essentialism is averse to views where laws are brute regularities or contingent features of our world. These views are associated with Categoricalism and the gap Categoricalism affords between properties and laws. This gap does not exist in Dispositional Essentialism. This is because, what a property does – what laws it follows – is essential to that property. The property's nature and essence are given by its relation to other properties. Thus, the relations between properties are fixed across worlds. Any world with charge is a world which follows Coulomb's law – the law which outlines how charged objects interact. So, laws are necessary – fixed across worlds. There is no room for mass to do what charge does and vice versa. The very nature of mass and charge is to act as they do. Their dispositions are fixed.

One of the main attractions of Dispositional Essentialism is that it provides an easy account of laws of nature in terms of properties. By referencing modal properties, lawfulness is explained. No regularities are left brute or contingent – happy accidents of our world. However, where does this leave laws of nature?

Within Dispositional Essentialism, properties are identified by their relations to further properties. However, these relations "look uncommonly like laws." (Swoyer, 1982, p. 214) After all, as we saw above, "laws" is often taken to refer to or to mean "relations between properties". This is true in both Categoricalism and Dispositional Essentialism, both of which commonly see laws as relations between universals (Tugby, 2015). Given that properties are identified by their relations to further properties, the very nature of properties is sufficient to explain laws within Dispositional Essentialism. Properties have essential and unchangeable ties to each other, so the laws of nature are necessary – dictated by the properties which give rise to them. I-worlds, where properties swap or

invert their roles are not possible within Dispositional Essentialism. Any world with charge is a world where Coulomb's law applies. The nature of charge mandates it.

The proximity between properties and laws is clear within Dispositional Essentialism. It lends itself to at least four interpretations of the relationship between properties and laws:

(P1) there are only properties as we have no need for laws
(P2) properties are fundamental and ground laws which are ontologically secondary
(P3) properties are constituted by laws which govern how properties behave
(P4) properties and laws are symmetrically dependent

I will go through these in turn.

The view that there are only properties and no laws (P1) is argued for in Mumford's book *Laws in Nature* (2004). He argues that either a) laws have a governing role or b) laws do not have a governing role. If a) is true, Dispositional Essentialism is false. This is because if laws have a governing role, properties are not doing the modal work and Categoricalism (as opposed to Dispositional Essentialism) is the case. So, if you endorse Dispositional Essentialism you must endorse b) – that laws do not play a governing role. Mumford argues that in light of b) – that laws do not play a governing role – we ought to eliminate them on the basis that they needlessly inflate our ontology.

There is some tension between Dispositional Essentialism's desire to ground all modality in properties and its commitment to laws. On the one hand, Mumford points out that properties seem to be doing all the work already. However, dispositional essentialists are rarely eliminative about laws of nature. This may be partially motivated by the fact that talk of laws is so embedded in the scientific discourse, eliminating them is quite a radical move. The biggest motivator for holding onto laws, in my view, is that laws provide a unifying explanation for why so many individual dispositions act in such predictable laws. Often many dispositions (e.g. magnitudes of charge, mass, etc.) neatly act in accordance with a single equation. Laws provide a way of explaining this cohesion. Next, I will look at two ways in which dispositional essentialists have tried to retain laws by saying that laws are derived from properties (P2) and that laws constitute properties (P3).

The most popular and representative view of laws among dispositional essentialists is (P2) – the view that dispositional properties give rise to laws (Ellis, 2001; Bird, 2007). Properties are fundamental and metaphysically prior. Bird sees "…the motor and cement of the universe as residing ultimately not in the laws themselves but rather in the dispositional nature of properties. The laws are, in a sense, epiphenomenal." (2007, p. 47). At the same time, the laws – as the relations between properties – are a crucial part of the dispositional essentialist story.

Laws are entailed by properties – the properties require the existence of relations to get their identity. Apart from being entailed by properties and being the glue that holds properties together, laws are very useful in scientific practice and in our prediction and navigation of the world. As such, I take P2 to be the most representative view of laws within Dispositional Essentialism. The fundamentality of properties and their metaphysically explaining laws is standard Dispositional Essentialism. As a result, this view will be my focus for the next chapters. In particular, I will be concerned with the problems facing this view and how we can respond to them in order to better account for laws of nature.

Another, though less popular, alternative to eliminating laws is to say that properties are constituted by laws (P3). Matthew Tugby (2015) has argued that this view is plausible given Mumford (2004) and Bird (2007). The idea is that laws are not eliminable. They are fundamental parts of the world. Laws constitute the properties of dispositionalists.

Tugby's argument starts by pointing out that laws within Dispositional Essentialism are structurally very similar to laws within the DTA view mentioned above. To recap, the DTA view is the view that laws are relations between universals which are contingently necessitated. The similarity lies in the fact that within Dispositional Essentialism laws are also treated as relations between universals (Mumford, 2004; Ellis, 2001; Bird, 2007). However, in this case they will not be contingently necessitated but rather are necessary. As we have seen, the nature of dispositional properties is fixed by their relations to other properties. As a result, those relations – the laws of nature – are fixed across all worlds.

Dispositional essentialists regularly talk of laws as relations between properties. Further, those relations give us the identity and essence of the properties in question.

And, on the pure dispositions view whereby properties are purely dispositional without a categorical basis (Bird, 2007; Mumford, 2004; Tugby, 2015) there is nothing more to dispositions than these relations. In light of this, Tugby argues that within Mumford and Bird's framework, laws constitute properties. Naturally, on this view it makes no sense to eliminate laws in favour of properties. Properties cannot exist without laws and laws dictate how particular instantiations behave.

Finally, I mentioned a fourth picture of the relationship between properties and laws that is compatible with Dispositional Essentialism. This is the view that properties and laws symmetrically depend on each other (P4). While I do not know of any philosopher who explicitly endorses this view, I find it to be highly motivated from a dispositionalist or structuralist perspective.

As we saw earlier, in Categoricalism there is a gap between properties and laws. This gap allows for laws to be contingent and for I-worlds where properties change, swap or invert nomic roles. Dispositional Essentialism closes this gap between properties and laws. Properties are like the relata and laws are the relations between them. (This image will re-surface in the following section where we look at how Bird represents properties and laws using graphs). What I envision here is that the relata and the relations symmetrically depend on each other.

Most philosophers assume that relations cannot exist without relata by definition. Mumford rejects the relations (laws) on the basis that the relata (properties) contain all the modal information. However, the existence of the relata is never questioned. In my view, it is not clear that the dependence goes from relata to relations – from properties to laws. The relata – properties - here are peculiar. *The nature of the relata is relational.* The nature and essence of properties is exhausted by the relations they enter into. This is exactly what leads Tugby to say that properties are constituted by laws (2015). At the same time, the laws are the very relationship between properties. They are constituted by properties. As such it is hard to see how we could have one – relations or relata - without the other. They both get their identities and essences in virtue of each other. Thus, it is hard to see how one could be metaphysically prior to the other.

Properties and laws are so close in Dispositional Essentialism that the project of pulling them apart, and giving one ontological priority over the other, is messy. I will go into depth and defend P4 – the symmetric dependence of properties and laws – in chapter 7.

For now, I set P4 aside. My focus is on P2 – the standard view within Dispositional Essentialism, that properties are fundamental and laws secondary. I will explore the problems this picture faces and how Dispositional Essentialism must change in order to address them.

2.3 Problems for Dispositional Essentialism's account of laws

2.3.1 Functional laws

Dispositional Essentialism's view of properties as fundamental, and laws as supervenient, has much appeal. *Prima facie*, taking properties with necessary nomic roles to be fundamental does away with the need to account for laws. Within Dispositional Essentialism laws cover the dispositions of properties. According to Bird, laws are of the type $\forall x((Px \wedge Sx) \rightarrow Mx)$ (2007, p. 46), which is to say that given a property P and its stimulus S, manifestation M will follow. However, this account is overly simplistic. In what follows I cover a few important problems Dispositional Essentialism's account of laws faces.

The first and main difficulty that Dispositional Essentialism faces in accounting for laws is the fact that contemporary physics is built out of functional laws. Here I follow Armstrong in taking a functional law to be "a determinable law that governs a class of determinate laws." (1997, p. 245) There are various ways of conceptualising the determinable-determinate relationship. For instance, determinables are often viewed as sets of determinates. Alternatively, determinables may be seen to differ from determinates in terms of specificity. Determinates are more specific than determinables. Either way we can get a sense of determinables and determinates by example. Red is a determinate of colour, however it is also a determinable of scarlet and crimson. Similarly, quadrangle is a determinate of shape, however it is a determinable of square and rectangle. As a result, a *determinable law* will be one that holds at the determinable level (for instance a law that is true of colour) and a determinate law will hold at the determinate level (in this case red, blue or yellow). If functional laws are determinable laws which govern determinate laws, they will be laws about determinables like colour, charge, or mass assuming these govern laws about determinates (particular hues of colour, magnitudes of charge or magnitudes of mass).

Functional laws are a problem for popular expositions of Dispositional Essentialism on the basis that these take determinate properties to ground laws. However, determinate properties seem like candidates for grounding determinate (as opposed to determinable) laws. Dispositional essentialists tend to favour determinate properties despite recognizing that the laws of science are functional (determinable). Chris Swoyer does this on the basis that there is reason to doubt that determinable properties exist, yet he accepts that this leaves unanswered questions. "If determinables are not genuine properties, the truth of a general principle must be explained by facts about determinates, rather than conversely. Moreover, we need to explain what it means to say that determinates fall under the same determinable." (1982, p. 219) Dispositional essentialists have yet to account for this, with the issue going unnoticed.

The difficulty Dispositional Essentialism faces accounting for functional laws stems from the fact that the properties that they say ground modality are determinate. The problem comes across clearly in Bird's popular exposition of Dispositional Essentialism (2007). Bird claims that there is no room for multi-track dispositions in our fundamental ontology. Multi-track dispositions are dispositions with multiple stimulus-manifestation conditions. On his view all fundamental properties are single-track meaning that they only have a single stimulus-manifestation condition.

The idea that only single-track dispositions are fundamental is based on the idea that multi-track dispositions can be reduced to a multitude of single-track ones. Bird argues that if a property has multiple stimuli and/or manifestations then it is not a fundamental one. Rather, it is a conjunction of multiple fundamental properties which are single-track. For instance, if property S has the following stimulus-manifestation conditions S12-M134 and S18-M134, then S is actually two properties: the property to manifest M134 when presented with stimulus S12 and the property to manifest M134 when presented with stimulus S18. These two properties have different stimuli[3].

Bird illustrates the relations between fundamental properties using graph theory. On his view, each fundamental dispositional property will have a single stimulus and manifestation condition. These stimuli and manifestations will be further properties. In the graph properties are represented by nodes or vertices. The relations they hold to

[3] It is worth noting that Bird allows for single-track dispositions with a complex stimulus condition, i.e. where various conditions must hold together to meet the stimulus condition (2007, p. 24). However, he does not allow for complex manifestations.

other properties (their stimuli and manifestations) are represented by lines between the nodes or vertices (see figure 1 below). This also has the advantage of showing how we differentiate properties from each other given the interrelations between them. Each property will be differentiated by its unique set of relations to other properties. "The identity and distinctness of the vertices of a graph can supervene on the structure of that graph." (Bird, 2007, p. 139) The lines between the properties are supposed to give us the modality of the world i.e. to explain the lawfulness we witness in nature. But let's consider what laws these graphs can really give us.

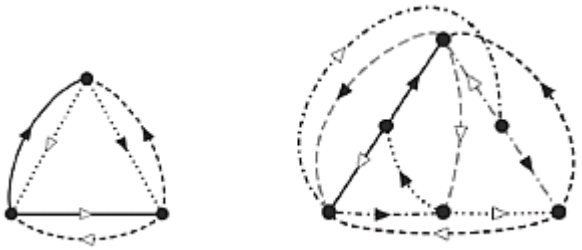

Figure 1 (Bird, 2007, p. 146)

According to Bird, laws within Dispositional Essentialism are of the type $\forall x((Px \wedge Sx) \rightarrow Mx)$ where P stands for a property, S the stimulus and M the manifestation (2007, p. 46). The idea is that given a property P and its stimulus S, manifestation M follows. However, as we saw, for Bird the fundamental or natural properties are single-track. So, that basically means that laws formalise a relation between a single-track property, its maximally determinate stimulus and manifestation.[4] I say that the stimulus and manifestations are maximally determinate because, if they were not, they would allow various determinate stimuli and manifestations. However, this would make them multi-track. Therefore, the stimulus and manifestations will be maximally determinate. The problem is that these properties only seem able to ground maximally determinate laws.

If laws of nature are of the type $\forall x((Px \wedge Sx) \rightarrow Mx)$ where a determinate property, taken with a determinate stimulus gives rise to a determinate manifestation, *only determinate laws are fundamental.* The problem for Dispositional Essentialism is that the basic properties in science (e.g. mass, charge, etc.) thus far have not been single-track. They have various stimulus and manifestation conditions. They are multi-track in Bird's

[4] Later in this chapter I will look at whether maximally determinate properties can be multi-track (Vetter, 2015). I set this issue aside for now as it distracts from the discussion regarding the scope of the laws dispositions metaphysically explain.

terminology. As a result, these properties cannot be fundamental for Bird, nor can the laws in which they enter. Since these laws range over many determinate laws they are determinable or functional laws (e.g. Coulomb's law, the law of gravitation). So determinable laws cannot be fundamental and are mere conjunctions of determinate laws. This leaves the determinable or functional laws of current science unexplained, as brute regularities of determinate laws – a situation which Dispositional Essentialism was set up to avoid (Vetter, 2012, section 3).

I will use Coulomb's law to illustrate Dispositional Essentialism's difficulty in accounting for functional, or determinable laws. Coulomb's law is a functional or determinable law since it outlines how any two charged objects interact (covering all combinations of determinate charges). In the dispositional essentialist's lingo it tells us how any charge (C) will manifest (M) when presented with stimulus (S). However, for Bird, these variables C, M and S are mere disjunctions of determinate Cs, Ms and Ss. As a result, the only laws which we can truly account for (assuming that the determinates here are not disjunctions too) are the determinate laws which outline how determinate charged objects interact. So Dispositional Essentialism can explain, for instance, why determinate charges {C1, C2, and C3} have determinate manifestations {M1, M2, M3} given a determinate stimulus {S1, S2, S3}. Since laws do not add new information, but trivially supervene on properties, this allows for the following laws within Dispositional Essentialism: 'When C1 is presented with S1 it manifests as M1', 'When C2 is presented with S2 it manifests as M2', 'When C3 is presented with S3 it manifests as M3', and so on. However, these determinate laws do not explain Coulomb's law, which states that S, C, and M (qua determinables) stand in a functional relationship. No explanation has been given for the regularity among the determinate charges and, thus, for Coulomb's law itself. Given how critical dispositional essentialists are of regularity views, they need to be able to account for functional laws without running into a regularity view themselves.

The difficulty Dispositional Essentialism faces accounting for regularities among determinates may be made worse by the threat of "vacuous laws". A vacuous law is a law which, for one reason or another, is never instantiated. This can happen either because a property is not instantiated – missing property - or because two properties never cross paths so that the relation is not instantiated - missing relation (Chakravartty, 2007, p. 141). As mentioned earlier, objects can have dispositions regardless of whether they are instantiated. A vase can be fragile regardless of whether

it ever breaks. Being fragile entails certain possibilities about the object that is fragile which need not materialise. Thus, I focus on the missing properties problem for Dispositional Essentialism. Let's disambiguate between two kinds of missing properties. There may be determinates (e.g. charge C235) which are not instantiated. Alternatively, there could be determinables which are not instantiated. I will call these alien properties following Lewis (2009) and Tugby (2013).

The issue of uninstantiated determinates is that we believe that there are facts about what laws those determinates would follow. In the case of an uninstantiated magnitude of charge we believe it will follow a determinate of Coulomb's law. Similarly, an uninstantiated mass would follow a determinate of the law of gravitation. However, it is not clear what makes these beliefs true in the dispositional essentialist's worldview. If we are only realists about determinate instantiated properties it seems that there are no truthmakers for uninstantiated ones. Rather, we make guesses about the behaviour of possible determinates from the pattern of regularities we witness, but nothing guarantees that our guesses are correct.

Chakravartty proposes various ways of circumventing this worry (2007, chapter 5). The first is inspired by Armstrong, who has an Aristotelian view of universals whereby only instantiated universals are real. On his view, statements about uninstantiated determinates have truthmakers in the determinable laws they instantiate. On his view, "The existence of the determinable universal is entailed by, and so supervenes upon, the existence of each and every determinate universal falling under it." (Armstrong, 1997, p. 247) So any one determinate mass or charge (for example) brings the determinable mass or charge into existence. The determinate law regarding that particular mass or charge, brings the determinable law into existence too. Determinable properties and laws then are necessary for us to know anything about uninstantiated determinates.

A second suggestion stems from the holistic nature of Dispositional Essentialism. The idea is that all properties are connected within Dispositional Essentialism. As properties get their identity from other properties, the existence of any property will eventually loop round, grounding truths about uninstantiated determinates.

> "The role of truthmaker can be served, not only by any one of the properties potentially involved in the relevant relation, by *any* property *whatsoever*. Recall

> that it is a consequence of DIT [Dispositional Identity Thesis] that networks of causal properties have a holistic nature." (Chakravartty, 2007, p. 146)

Picture Bird's graphs. Every property will eventually (even if with some degrees of separation) connect to every other property. So, every property fixes the facts about every other property.

The issue of uninstantiated determinables is more or less troublesome, depending on your point of view. It is less troublesome if you do not accept the possibility of alien properties. However, this is very hard to justify *a priori*. At best we have an argument from Ockham's razor to their non-existence but this is hardly decisive (Lewis, 2009). Again, Bird's graphs creeps in. As Tugby put it, "unless we take our world to be metaphysically privileged in some way, we would have to be lucky to belong to a world which spatiotemporally instantiates all the properties in the transcendent graph." (2013, p. 477)

Armstrong's strategy cannot help with truthmaking with regards to statements about uninstantiated determinable properties and laws. After all, being uninstantiated these will not have a corresponding truthmaking universal. If we are concerned about alien determinables we can endorse a Platonic view in which all universals exist, not just the instantiated ones. It is worth noting that some dispositional essentialists are open to Platonism like Bird (2007) and Matthew Tugby, who gives a full exposition of Platonic Dispositionalism in his 2013 paper of that name. How does Chakravartty's suggestion fair?

Recall that Chakravartty suggested that, within Dispositional Essentialism, every property could serve as a truthmaker for facts about every other property and the laws it follows. The relations between properties (the laws) go all the way round the holistic structure, so they are fixed by the properties which exist. The issue is that, within a Bird-like framework, it will be the case that any instantiated determinate property is linked to every other possible or actual determinate property. However, this would still leave us with a bunch of determinate laws. The determinable level is left unexplained.

Alien properties aside, in my view Chakravartty's solution still requires realism about determinable properties. Without determinables we risk a regularity view. This would not be a regularity view in Lewis's sense where properties are freely recombinable.

Given the commitment to properties having dispositional essences that would not be possible. Nonetheless, the existence of unifying determinable laws would go unexplained. The fact that so many determinates obey a single law would be an unexplained regularity, a seemingly miraculous accident. This goes against Dispositional Essentialism's aim of accounting for all modality, rather than leaving it brute.

In my view, realism about determinables neatly solves the problem of uninstantiated determinates. If the determinable property and law exist, they explain why uninstantiated determinates are bound to follow certain laws. I will not take sides on the issue of uninstantiated determinables. If you take an Aristotelian stance, and do not believe in uninstantiated universals, this may not be a problem for you. If you do believe in alien properties, you have the options of pairing your realism about determinables with either a) a platonic view whereby all determinables exist (see Tugby, 2013) or b) Chakravartty's holism. However, the most persuasive reason for my proposed solution is that realism about determinables would help solve the larger problem of accounting for functional or determinable laws within Dispositional Essentialism. The fact that it helps account for vacuous laws is a bonus. Thus, in my view, the way forward is to reject Bird's dogma of maximally determinate properties which causes more trouble than it is worth. I do the argument for determinables justice in the next chapter, for now I will look at some other problems for Dispositional Essentialism's account of laws.

2.3.2 Laws are complex

The second problem for Dispositional Essentialism's account of laws stems from the idea that laws are of the type $\forall x((Px \wedge Sx) \rightarrow Mx)$ where P stands for any property, S for its stimulus and M its manifestation.

We saw that Bird articulates properties and laws in terms of stimulus-manifestation conditions. For instance, he says that "The manifestation of charge is a force on some other charge, its stimulus is the magnitude of that other charge." (Bird, 2007, p. 21) Presumably, a formalisation of this would give us Coulomb's law. The problem is that, this is not what scientific laws look like. Barbara Vetter is quick to point out that the laws in question do not even mention stimuli or manifestations (2012; 2015). Scientific laws relate quantities.

Coulomb's law (see the table below) determines the electrical force (F) by multiplying the charges of the objects (Q_1 and Q_2), dividing their sum by the square of the distance between them (r^2), and multiplying the result by Coulomb's constant (K). So, the electrical force is proportional to the charge of the objects and inversely proportional to the distance between them. Newton's law of gravitation determines the gravitation forces (F) in function of the mass of two objects (M^1 and M^2) and the square of the distance between them (r^2), all of which are variable quantities. In particular, it tells us that gravitational force is proportional to the mass of the objects but inversely proportional to the distance between them. And Einstein's mass energy equivalence determines the quantity of energy (E) in function of the quantity of mass (M) which is multiplied by the square of the speed of light (C^2).

Coulomb's law	$F = K \frac{Q^1 Q^2}{r^2}$
Newton's law of gravitation	$F = G \frac{M^1 M^2}{r^2}$
Mass energy equivalence	$E = MC^2$

Bird's model of laws within Dispositional Essentialism - $\forall x((Px \wedge Sx) \rightarrow Mx)$ – oversimplifies things. Dispositions are not absolutes which either hold or do not hold. They come in degrees or quantities. Laws do not speak of stimuli and manifestations but relate quantities. Further, they may relate more than three entities (whereas Bird can only allow for laws which relate 3 properties – they relate the property in question to its stimulus and manifestation). For instance, Coulomb's law allows for the input of two charges, a distance and that gives us the force between the two objects. Here I will not take sides on whether all these properties are legitimate, intrinsic or extrinsic, fundamental or not. The point is that scientific laws are varied and take on a plethora of different forms. They are not reducible to a simple formula. Dispositional Essentialism is faced with two options. It can cling to Bird-like views that laws are of a certain type and claim that any laws which do not fit the mould are not fundamental. Alternatively, it can allow properties to relate to each other in more flexible ways. I choose the second option for multiple reasons.

First, Bird has not actually succeeded at persuading other dispositional essentialists that properties and laws must fit the narrow confines he places upon them. There is precedent within Dispositional Essentialism for properties with multiple powers (Mumford, 2014 - see next chapter). Additionally, Vetter argues that dispositions are multi-track, that conditional analyses fail to capture how properties and laws work, and that dispositions need to be flexible to account for laws such as the above (2013; 2015). This leads Vetter to say that we are better off leaving stimulus out of the picture and characterising dispositions by their manifestations only (2015, p. 65). Further, Marmodoro argues that stimulus-manifestation models miss the point of the reciprocal exchange between powers (2017).

Second, it takes a very powerful case to establish each of the *a priori* constraints Bird's places on properties and laws individually. It takes a strong case to show that a) properties (and/or laws) must be maximally determinate, b) properties are single-track, c) laws relate exactly three things (stimulus, property they are about and their manifestation) and d) all laws will conform to the simple formula he suggests. Each of these constraints is contentious, especially given that science (and philosophy according to my argument) is leading us away from his conclusions. It seems too quick to dismiss current successful physical laws on the basis that they are functional, do not conform to a bog-stand formulation of laws, or relate more than three things (stimulus, property, and manifestation).

2.3.2.1 Functional laws re-visited

In light of Vetter's critique, I must rephrase the first problem for Dispositional Essentialism – the problem of accounting for functional laws. I argued that it is was hard for dispositional essentialists to account for Coulomb's law given that it is a functional law which ranged over many charges, stimuli, and manifestations. However, as Vetter shows, things are more complex. Coulomb's law does not mention stimulus or manifestations. What Coulomb's law tells us is that the electrostatic force of attraction between two charged objects is directly proportional to the product of the charges and inversely proportional to the square of the distance between them.

Maximally specific solutions to Coulomb's law, as given by Bird's properties, would give us maximally determinate versions of this law such as "(CL∗) For all x, if x has charge e and is 5.3×10–11 m from a charge of 1.6×10–19 C, then x exerts a repulsive force of

8×10–8 N." (Vetter, 2015, p. 57) The problem is that these are utterly uninteresting and uninformative when compared to the general law.

Laws which only outline how a property manifests in a maximally determinate circumstance are useless – they do not allow us to predict what will happen in other circumstances. Further, they do not give us interesting information about the world in the way that the general law does. (CL*) does not reveal to us the fact that the force between two charges is directly proportional to the product of those charges, and inversely proportional to the square of the distance between them. That information cuts to the heart of charge, giving us interesting information about its very nature.

In addition to being uninformative, without an explanation for the relation between these determinables we are left with a regularity view of laws where the similarities between (CL*) and other determinate laws are left brute. The fact that so many things follow the general law is left unexplained which goes against the explanatory aims and promises of Dispositional Essentialism.

The dispositional essentialist is left in an awkward position. The fact that all determinate charges behave in similar ways, so similar that their behaviour to be predicted by a single equation, calls out for an explanation. The regularities cannot be left brute, with functional laws inferred from them. That is tantamount to taking a Humean regularity view of laws (or at least determinable laws). Yet one of Dispositional Essentialism's major selling points is its anti-Humean attitude – taking laws to be written into properties rather than mere regularities. Worse, Dispositional Essentialism's inability to account for higher-level determinable laws undermines the power of the theory to explain the lawfulness of nature – one of its main selling points. If laws are made on a case by case, determinate, basis they seem *ad hoc* and lose their explanatory power. Little or no information is given by showing that a determinate property manifests a determinate way in a determinate situation. Impressive advances in science occur when high-level determinable laws are formulated which explain and predict the behaviour of many determinates.

2.3.3 Global Principles

Even after solving the previously mentioned problems for Dispositional Essentialism a third and perhaps greater problem awaits Dispositional Essentialism. The issue is that

Dispositional Essentialism has little or nothing to offer by way of an account of global principles. Roughly, global principles are higher-level laws than regular laws like Coulomb's law. They do not hold of individual objects and their properties, so they cannot tell us information like what force a massy object is exerting or what dispositions a charged object has. Rather, they hold of the whole universe. These high-level laws appear to explain what happens at the local level rather than the reverse. So, if the universe conserves mass-energy that explains why any local loss of mass or energy will be paired with a gain somewhere else.

Global principles are quite diverse. The best-established global principles include symmetry laws, conservation laws and the principle of least action. The principle of least action tells us that, when in doubt about how a system evolved, the option which required the least action is correct. We can visualise least action as the shortest trajectory between two points, however this is not technically correct. Action is a technical term for the difference between kinetic and potential energy over time. When we want to decide how a system evolved, the principle of least action tells us that the trajectory which involved the least action occurred (Katzav, 2004). Symmetry laws are closely tied to the concept of invariance. Symmetry laws outline what sort of transformations things can undergo without changing in other ways e.g. translation in space-time, spatial rotation. For instance, the speed of a train could change without affecting the laws of physics inside the train. Symmetry principles constrain which particles are able to exist leading to the famous prediction and discovery of the Higgs boson (French, 2014, p. 271). Conservation laws are laws regarding certain physical quantities which remain constant in the universe e.g. mass-energy, angular momentum, momentum, number of leptons.

Bird recognises the problem of global principles in a small section of his concluding chapter in which he quickly dismisses these laws as "pseudo laws" to be explained away by future science (2007, p. 214). His dismissal is not convincing for two reasons. First, because contemporary physicists take global principles so seriously that they posit symmetries as fundamental in nature (McKenzie, 2012). Not only do these global principles appear to govern all interactions but they have proved incredibly fruitful. They constrain which particles are able to exist, allowing the prediction and discovery of the Higgs' boson (Ibid). The second reason Bird's treatment of global principles as pseudo-laws is unconvincing is that he never gives an independent argument for it. He simply states that we should endorse it because it fits better with Dispositional

Essentialism. Within Dispositional Essentialism laws stem from the dispositional essences of properties so there is "no room for further constraints." (2007, p. 214) Given how well established and fruitful global principles are to contemporary science their dismissal warrants a strong argument.

This is all very brief. These laws deserve a much greater exposition and so they will be the subject of two chapters. In chapter 4, I will look at global principles. I look at what they are, how they have been accounted for and why those accounts are unpopular. I also forward my own novel strategy for accounting for global principles within Dispositional Essentialism. Then, in chapter 5, "Case studies in accounting for Global Principles: Conservation laws and the Principle of Least Action", I do a deep dive into a couple of examples of global principles, so that we can see these explanations applied to real cases.

For now, suffice to say that these principles present a great, and often ignored, problem for Dispositional Essentialism. This is because it is hard to see how they can be the manifestations of ordinary properties' dispositions. Again, a Humean view of these global principles as regularities is not open to Dispositional Essentialism. Leaving highly explanatory scientific laws brute or unexplained is exactly the sort of thing Dispositional Essentialism is supposed to avoid.

Conclusion:

Dispositional Essentialism arose in opposition to Categoricalism. Dispositional essentialists believe that what properties do – their nomic roles – reflect what they are – their essential nature. On the standard view, the dispositions of properties give rise to laws. This allows for necessary laws, avoiding regularity views or contingent laws. However, as we have seen, there are problems with the standard view. The most pressing and first to address is that it is hard to see how we get from properties to laws. This is because, the properties in question are often assumed to be maximally determinate or single-track (Swoyer, 1982; Bird, 2007) yet the laws are functional or determinable. In the next chapter I will argue for what I take to be the solution: realism about determinables. I will do this by showing the motivation for realism about determinable properties, that there is precedent for more complex properties within

Dispositional Essentialism (Mumford, 2004; Vetter 2012, 2015) and that realism about determinables neatly solves the issue at hand. After I have shown how dispositional essentialists can account for laws in general in chapter 3, I will look at ways in which they can account for global principles in chapters 4 and 5.

3. Realism about Determinables

In the previous chapter we saw that the main difficulty Dispositional Essentialism faces in accounting for laws is the fact that the laws of physics are functional or determinable. In this chapter, I articulate my proposed solution to the problem. I argue that if dispositional essentialists are realists about determinable properties the problem goes away. I argue this by showing the motivation for realism about determinables and showing that there is some precedent for this view within Dispositional Essentialism. After arguing for realism about determinables within dispositionalism, I will go on to explain the relationship between determinables and determinates on my view.

3.1 Determinables and determinates

In the previous chapter we saw that determinables are more general than determinates. Determinates like "crimson", "maroon" and "scarlet" fall under the determinable "red". Yet what exactly red is is up for debate. Is red real? Is it an abstraction or set of determinate reds? To answer these questions, let us look at what can be said about determinates and determinables generally.

There are many determinates in existence, and many more could be instantiated. In addition to every shade of red (or every shade of colour at all), there are all the determinate shapes, charges, masses, pains, pleasures, angles, sounds, etc. That said, you can't just make a set of a few determinate sounds, crimson and half a dozen charges and plausibly claim to have a determinable. Even if you thought that determinables were mere sets of determinates, those sets are not random. Determinates which fall under the same determinable have a special relation to each other (Johansson, 2000; Funkhouser, 2006; Wilson, 2012). In particular:

a) Determinates under the same determinable resemble each other in a way that they do not resemble determinates of different determinables (e.g. yellow resembles blue in a way that it cannot resemble circular or square)
b) Determinates of the same determinable are mutually exclusive
c) If something has a determinable property it must have a determinate property

d) Determinables do not fix determinates

e) Determinates fix determinables

Regarding a) determinates which fall under the same determinable are both similar and different in particular ways. Determinates of a determinable are like each other in a way that they are not like determinates of other determinables. Further, this similarity admits of degrees. So "blue" and "green" are similar in a way that "blue" and "square" can never be. Further, "blue" and "green" are more like each other than "blue" and "orange". That said, "blue" and "yellow" may be equally similar to "green". However, "blue" is no more similar to "circular" than to "square". In fact, there is a sense in which these are utterly dissimilar and cannot be compared at all.

In addition to sharing similarities, determinates importantly differ. As outlined in b). Determinates of the same determinable are mutually exclusive. Something cannot be "blue" and "red" at the same time (more on this below). Nor can something be both a "square" and a "circle". In fact, square-circles are the archetype of logical impossibility, frequently brought up alongside 2 plus 2 being 5. On the other hand, determinates of different determinables do not usually exclude each other.[5] Objects (even simple objects like particles) have determinates of various determinables. Electrons, for instance, have size, mass and charge. Back to our example, a thing may be blue and square, blue and circular, red and square or red and circular. We would not expect the blueness of a thing to dictate its shape or vice-versa.

It is worth noting that at least one prominent writer about this topic allows for some determinables (or some determinates which fall under different determinables) to resemble each other in certain ways. Nonetheless, they will retain important differences. Eric Funkhouser (2006, 2014) paints a detailed picture of determinates and determinables based on the idea of determination dimensions. In his view, properties feature certain determination dimensions. For instance, the determination dimensions of colour are hue, brightness and saturation; those of sound are pitch, timbre and loudness.

[5] Determinates of different determinables can mutually exclude each other in special circumstances. Size and colour provide an example. The determinate "being particle sized" might exclude all determinate colours. However, that is not to say that size determinates and colour determinates exclude each other. Objects of many determinate magnitudes of size can be coloured.

On Funkhouser's view, maximally determinate properties – known as super-determinates – have maximally specific values of their determination dimensions. For instance, a maximally specific shade of red has a precise hue, brightness and saturation. In contrast, determinables range over certain values of the determination dimensions. Red will range over all the values of hue, brightness and saturation which, if instantiated, would produce determinate reds. Colour, on the other hand, is a super-determinable. It ranges over the entire determination dimensions i.e. over all combinations of hue, brightness and saturation. It is a super-determinable because it is maximally unspecific with regards to the determination dimensions.

Determinates under the same determinable resemble in certain ways. They all share the same determination dimensions. As a result, determinates under the same determinable can be compared along those dimensions. They differ from determinates of other super-determinables according to which values of determination dimensions they have. So, all colours have hue, brightness and saturation. They may be more or less similar on one or all of these dimensions. If three colours differ only with respect to hue, the two with the closest values of hue will be more like each other than the third. However, if they differ on various dimensions then perhaps it will be impossible to decide which are most dissimilar.

Funkhouser leaves room for determinates under different determinables to partially resemble or be compared on specific determination dimensions. This is because he allows for the possibility that determinables can share some of their dimensions. Say determinable X and Y have the determination dimensions {A, B, C} and {B, D, E}. If this is possible, then determinates of X and Y would share a determination dimension - B. As a result, we may be able to compare them along this dimension and they are not utterly incommensurable.

Jessica Wilson criticised Funkhouser's use of determination dimensions. She pointed out that his favourite example – colour – might have different determination dimensions according to the discipline studying it. While he claims that the determination dimensions of colour are hue, brightness and saturation, a scientist might say that they are spectral power distributions (Wilson, 2006). Funkhouser has various responses to this, remaining neutral on what exactly the dimensions are. He says "I am not concerned with defending any substantive thesis about the nature of *colour, pain*, etc. So it very well might be the case that *colour* possesses determination dimensions different

from the three—hue, brightness, and saturation" (2014, p. 58) Funkhouser leaves this to science and retreats to neutrality as metaphysicians often do. He aims to give an abstract recipe for understanding determinates and determinables along determination dimensions. This abstract recipe, if true, holds independently of what those turn out to be.

For my part I remain neutral on whether determinates and determinables can be mapped out on determination dimensions. I accept the traditional differentiators of determinates and determinables outlines in a) – e), leaving open how we flesh that out. What I take from Wilson and Funkhouser's exchange is that, if Funkhouser's picture is right the question of which determination dimensions properties have is very much open. Additionally, there is the issue of whether determinables can share dimensions. However, even if determinables may share determination dimensions, determinates under different determinables will still share significant differences. They will still importantly differ in virtue of having different determination dimensions. So, under all these popular expositions of determinates and determinables b) stands i.e. determinates of the same determinable are mutually exclusive

In addition to having certain similarities and dissimilarities, determinates and determinables have special entailment relations. As mentioned in c) it is commonly assumed that for an object to have a determinable property it must have a relevant determinate property. So, for an object to be coloured it must be a particular shade. Similarly, for an object to have a shape it must have a particular shape. This has only recently been challenged by Wilson who argues for indeterminate properties (2016). I will not challenge the received view that instantiated properties fall under one determinate or other e.g. that every instantiation of colour is a particular shade. This issue is tangential to my case for realism about determinables.

An object having a determinable means that it has a determinate. The determinable implies some determinate. Yet, it is worth nothing that the determinable does not fix the determinate (d). Saying that an object is coloured does not tell us anything about which determinate shade the object is.

While determinables do not fix determinates, the reverse is not true. As per e), determinates do fix determinables. Any object with a determinate property has all the relevant determinable properties that this property is a determinate of. So, if an object

is crimson, it is necessarily red and coloured; if an object is round, it is necessarily shaped, etc. This asymmetry of entailment between determinates and determinables will be of importance in the next section which looks at anti-realism about determinables.

3.2 Determinables as second-class properties

Philosophers have been realists about determinates but often apathetic, deflationary or anti-realists about determinables. The emphasis on determinates is seen when Lewis says that fundamental properties "are not at all disjunctive, or determinable, or negative" (2009, p. 204). As we saw, Bird follows this tradition in saying that fundamental properties are single-track. Single-track properties will be maximally determinate because they have one maximally determinate stimulus and one maximally determinate manifestation, leaving no room for variation. Further, the prevalence of this assumption in the dispositional essentialist literature can be traced back to at least 1982 when Swoyer noted the difficulty accounting for determinable dispositions and laws (p. 219). The idea of invoking determinables did not seem to even occur to him.

The emphasis on determinate properties is somewhat inspired by the notion of abundant properties and the pressure that puts on philosophers to slim down their ontology. Abundant properties, as a category, includes every possible property. As a result, this group includes regular properties (e.g. the property of being red), negative properties (e.g. the property of being not-red) and conjunctive properties (e.g. the property of being Obama, the Eiffel tower or number 2). In order to avoid a situation where we have endless gerrymandered properties, and to emphasise the properties that are important, Lewis forwards the notion of "natural properties" (1983, p. 346) which he elsewhere calls fundamental (2009, p. 204). On his view these are the only properties we need in our fundamental ontology. Bird uses this notion in his book, making it clear that his concern is with fundamental natural properties (2007, p. 243).

According to Bird "The fundamental natural properties are those with non-redundant causal powers." (2007, p. 13) What does this have to do with determinates? There seems to be an implicit assumption that the fundamental natural properties are maximally specific or determinate. Again, this can be traced back to Swoyer (1982) who assumes

that properties are determinate despite acknowledging the problem of accounting for determinable laws with them. Similarly, Bird claims that only single-track dispositions – dispositions with a single determinate stimulus and manifestation condition – are fundamental (see previous chapter).

There are at least two broad components to the trend of taking determinates, as opposed to determinables, to be fundamental. The first is the belief that all instantiated properties are determinate. So, any object with mass will have a particular mass, any object with charge will have a particular charge. This intuition is widespread to the point that it is assumed by those who are not interested in the determinate/determinable debate.

The expectation is that instantiated properties are determinate, and there may or may not be room for determinable properties. For an object to have a property X, it must have a maximally determinate property. If X is a superdeterminate that will be X, if not it will be a determinate of X. We saw this above when we looked at criterion c) "If something has a determinable property it must have a determinate property". So, we know that objects possess determinates, the question is whether they possess, in addition, determinables. Determinables are thus forced to earn their keep.

The less than realist attitude towards determinables comes, first, from the assumption that all property instances involve a specific – superdeterminate - property. Second, and more importantly, many philosophers do not think determinables earn their keep. This paired with parsimony concerns (we will look at these soon) led philosophers to exclude determinables from their fundamental ontology.

The main driving force behind the scepticism about determinables is that determinables do not appear to contribute anything new to our ontology. The idea is that determinates have all the causal powers necessary to account for events. Determinables have no new causal powers, at most they possess a subset of the powers of the determinates. This is supposed to hold whether we take properties to have their powers contingently or essentially (Gillett and Rives, 2005). That said, I will assume that they have causal powers essentially as my focus is on how Dispositional Essentialism accounts for laws. I will be arguing that realism about determinables allows Dispositional Essentialism to account for functional or determinable laws. However, for now I will return to the concerns philosophers have with determinables (ibid).

Stephen Yablo's work is often invoked to argue for the fundamentality of determinates and the idea that determinables are unnecessary for the causal story. Further, it shows why some philosophers say that determinables only have a subset of the powers of determinates. Yablo's famous example invokes a smart pigeon called Sophie (1992). Say Sophie has been taught to peck at red objects. She is pecking at a red object. This could be explained by the fact that the object is red. It could equally be explained by the fact that the object is crimson. The determinate and determinable explanation seem interchangeable. Now consider the case where Sophie has been trained to peck at crimson objects only.

Sophie is pecking at a crimson triangle. She has been trained to peck at crimson objects. The fact that the triangle is crimson already determines that Sophie will peck on it. There is no need to explain her behaviour also by the fact that the triangle is red. Further, explaining her pecking by the fact that the triangle is red leaves something out. After all, there are many red objects that she will not peck at (scarlet objects for instance). However, this leads to the odd conclusion that the triangle being red is irrelevant to the pecking incident.

Perhaps the best known view of determinables is the subset view. While I do not endorse this view and will argue for my strongly realist view soon, it highlights interesting facets of the determinate-determinable relation. The subset view dates back at least to Fales (1990). On this view, determinables have a subset of the causal powers of determinates. This is seen in Yablo's example. Red will have a certain causal profile. All the determinate reds will have to abide by that profile. However, those determinates also have additional powers. In the example, crimson has the power to make Sophie peck. Let us say that maroon has the power to make me buy clothes and that I will buy anything maroon that crosses my path. Then maroon has an additional power to red. We could give many more examples because determinates have a more detailed causal profile in virtue of their more specific nature. Determinables have more watered down causal profiles so as to be flexible enough to apply to all their determinates.

The subset view is often discussed in the context of philosophy of mind and multiple realisation. Pain is often given as an example of a mental property that is functional and multiply realisable. There are many physical brain states which can realise the mental state of pain. Just as pain is multiply realisable, some claim that determinables are multiply realisable properties too (Shoemaker, 2001). For instance, red may be realised

by crimson, maroon, burgundy, scarlet, etc. Any determinable can be realised by all the determinates under it.

The subset view contrasts determinates and determinables by the scope of their powers. It was mostly discussed in the context of views of properties as essentially causal or dispositional despite these views being in a minority at the time (Wilson, 1999; Shoemaker, 2001). According to the subset view, determinables have a subset of the powers of determinates. This view is not meant to eliminate determinables. Nonetheless, it gives the impression that determinables do not exist over and above their determinates. As a result, it is often used to argue that determinables are superfluous and ought to be done away with.

The subset view is the view that determinables have a subset of the powers of determinates, and no novel powers of their own. Gillett and Rives (2005) point out that if we pair this view with other concerns, we have a strong case for rejecting determinables altogether. The following points are brought up as damning for determinables:

(i) Overdetermination
(ii) Determinates explain determinables but not vice versa
(iii) Ockham's razor

The previous concerns are all interrelated. They all point to the idea that determinables are unnecessary, determinates do all the work already. As a result, I believe these concerns can be jointly tackled by showing that determinables earn their keep. However, for now I will explain each concern in turn.

The first concern is known as the overdetermination or double-counting concern. This concern invokes the commonly held belief that overdetermination is undesirable, so a theory which overdetermines ought to be replaced by one which does not where possible. If event X is overdetermined that means that there are two or more causes for X. The issue is that each cause is individually sufficient to cause i.e. to determine X. For instance, imagine that I ask why daffodils are yellow and you give both a scientific explanation and also say that there is a fairy which paints each daffodil every morning. There is a sense in which these answers are competing. Which one is it? Are daffodils yellow because of their properties or because the fairy paints them? If the properties are

sufficient to account for the yellowness of the daffodils, we need not invoke fairies. If we need fairies to paint daffodils yellow, their properties are not sufficient causes of their yellowness.

The overdetermination concern creeps into the debate on properties. Say Sophie the pigeon pecks at *all* red objects. In that case, we can explain Sophie's pecking an object both in terms of the fact that it is red and crimson. I could say "Sophie is pecking that object because it is red" but I could also say "Sophie is pecking that object because it is crimson". What Gillett and Rives point out is that here we risk double counting. In other words, we risk positing two separate properties as causes – crimson and red – where only one is needed.

One straightforward response to the overdetermination concern is Shoemaker's (2007). He believes that the subset view actually saves determinables here. This is because, on his view, determinates and determinables are not competing causes. They do not compete in the way the daffodil's properties and the painting fairies competed with each other. Rather, they are contributing the same causal power to the story. Thus, we are not counting two causes where there is one. As Wilson put it, "a higher-level property is not in causal competition with its lower-level realizer base property, since the conditional causal powers of the former are a subset of those of the latter. (Wilson, 1999, p. 51) I think there is something to this answer. Determinates and determinables have a special and close kind of relationship. However we flesh this relationship out, it seems clear that a determinable is not contributing a completely unrelated causal power to the story. I will say more on what role I take the dispositions of determinables to play later in this chapter.

The second concern stems from the fact that determinables are explained by determinates but not vice-versa. We saw this earlier in 3.1. In particular, we saw that:

c) If something has a determinable property it must have a determinate property
d) Determinables do not fix determinates
e) Determinates fix determinables

This is potentially problematic for determinables because they appear superfluous. Recall that determinables are multiply realizable properties with only a subset of the powers of determinates. Determinables cannot give us the full story of the world.

Determinables cannot account for which determinates are instantiated. The issue is that those hostile to determinables can argue that determinates can give us that full story. We do not need "red" to explain why Sophie pecks, "crimson" will do.

The third and related concern regards parsimony. Ockham's razor famously mandates that we must not multiply entities beyond necessity. The "beyond necessity" part is vital. It tells us that, all else equal, we ought to favour more parsimonious views. However, if a less parsimonious view is vastly explanatorily superior we can claim necessity. We can say that the parsimony cost associated with that view is outweighed by its explanatory benefits.

The key issue for determinables, which runs through all their criticisms, is that they do not seem necessary for explanation. We do not appear to need them in our ontology. Determinates seem perfectly able to do all the work. If determinables do not have a vital explanatory role, i.e. if determinates explain the determinables, then we ought not postulate them. The best response to these issues is to show that determinables earn their keep. In other words, determinables are necessary and bring explanatory benefit beyond what determinates can do. If determinables can earn their keep – and next I will argue that they do – then we have reason to be realists about them after all.

3.3 Realism about determinables

In the previous section we saw that realism about determinables is often met with scepticism. Determinables are often seen as unnecessary so that positing them overdetermines events and violates Ockham's razor. Those sceptical of determinables assume that determinables do not give us any additional information over what determinates do. They are unnecessary theoretical postulates. They do not enrich our explanation of the world. If anything, they confuse it. Determinables add unnecessary junk to an otherwise elegant ontology. I will show that this is not the case. There is important work for determinables to do. They give a unified explanation for modality. Determinables fill the explanatory gap that determinates leave, the gap between specific properties and general laws. Thus, I argue that if we want an elegant ontology, we ought to bring determinables into the fold.

The debate concerning determination has mostly assumed that determinates are fundamental and determinables are secondary, if real at all. However, recently there has been some work advocating for realism about determinables by showing that determinates don't do all the work after all. Determinables have an important explanatory role to play in our ontology. Recall the difficulty Dispositional Essentialism faces accounting for laws of nature. There is little to no interest in discovering how each determinate behaves and formalising that into a law that only applies to that determinate. The interest lies in determinable laws which allow us to predict the behaviour of their many determinates. Further, the fact that so many determinates fall under the same determinable laws calls out for explanation (Wilson, 2012; French, 2014). As we saw, functional laws have a kind of unity to them. They relate determinable properties, applying to all determinate instances of those properties.

As we saw, on the powers view determinates (e.g. determinate charges C_1, C_2 or C_3) will have determinate powers. However, all these determinates follow the same law – Coulomb's law. The fact that a single equation can predict how every determinate charge will manifest needs explaining. Without explanation the regularity is left brute. Of course, a Humean regularity theorist could bite the bullet and say that these regularities are brute and unexplained. However, the idea that they all randomly happen to behave in this way will not be satisfactory for the dispositional essentialist or any philosopher who aims to explain laws and ground modality. And, of course, my interest here is exactly in formulating an explanation of laws which works for Dispositional Essentialism. Further, there is the problem of vacuous laws. Perhaps certain charges are not instantiated in this world. Yet, we believe that if those charges were instantiated they would obey Coulomb's law – the determinable charge law. Other determinates cannot account for this. After all, it is hard to see how the causal profile of one determinate could influence the causal profile of any other determinate.

Wilson (2012) is a vocal advocate of determinables. She argues that it is a mistake to think that determinates suffice or, to use the popular metaphor, are "all god needs" in order to create our world. On her view, those who believe this assume that all that needs grounding are non-modal facts. This can be traced back to Ellis who said that the assumption is that "everything that is the case about the world is the sum over all times of everything that is the case at any one time." (1999, p. 65) This assumption is easily denied on the basis that modal facts are part of the world and, thus, must be explained

by the fundamental base. Given that determinates cannot do this, we must include determinables in our fundamental ontology.

Wilson uses the fact that laws of nature are going unexplained to argue that determinates do not fix determinables at all. In the interest of grounding both modal and non-modal facts, Wilson claims that determinables are just as fundamental as determinates. The two belong in our fundamental base. Determinables are required in our fundamental base to give us facts about the natural modality expressed in functional laws. However, once the modal facts are fixed, we still need determinates to tell us what is actually instantiated in our world. "more specific facts — concerning determinate properties, in particular — require existential witnesses, so to speak; and the facts about determinable properties cannot, it seems, do the job." (Wilson, 2012, p. 9) So, we need determinates.

One issue for Wilson's view is that determinates can still be argued to be modal. I discuss this more in chapter 7 (section 7.4.4). However, briefly, if the determinates are dispositions then, by definition, they are modal. Their very essence is given by their dispositions i.e. by their modal relations to other properties or to their potential manifestation. This is further seen by the fact that a disposition need not manifest to be there, it contains the modality whether or not it has an opportunity to manifest that. I don't think we can say that determinates are non-modal qua Wilson. However, Wilson is definitely onto something here.

Determinates can only ground narrow modal facts about how determinates interact. Yet, determinates under the same determinable obey incredibly succinct laws to the letter. This needs explanation. Here is where determinables come in. Wilson's idea is that we need determinables to ground the modal facts about why determinates obey the same determinable laws and are perfectly synchronized to this larger modal picture. The fact that we need determinables for these modal facts and determinates to provide 'existential witnesses' for what is actually instantiated in our world is echoed in French's work (2014) which we will look at when we discuss Ontic Structural Realism in later chapters. (More on the relationship between determinates and determinables in chapter 7.)

While Wilson suggests that determinables and determinates are *on par*, Barbara Vetter goes a step further. She suggests that "the general dispositions are not only as

fundamental as the specific ones, they are *more* fundamental". (2015, footnote p. 57) She argues this on the basis that particular instances of dispositions or laws like Coulomb's law are so explanatorily poor they appear less fundamental than the general versions. Recall the particular instance of Coulomb's law "(CL∗) For all x, if x has charge e and is 5.3×10–11 m from a charge of 1.6×10–19 C, then x exerts a repulsive force of 8×10–8 N" (Ibid, p. 57). (CL*) lacks the insight of the general law. It does not give us the information that the general law – Coulomb's law – does. It does not tell us that the electrostatic force of attraction between two charged objects is directly proportional to the product of the charges and inversely proportional to the square of the distance between them. Yet this seems essential to the nature of charge. The general law gives us more interesting insight and information into the nature of reality i.e. like charges repel each other, opposite charges attract each other.

In my view, we need both determinables and determinates in our fundamental base. Without determinables we cannot get the high-level modal facts. For now, I hope to have shown that there is an important role for determinables in our ontology. While Wilson and Vetter have pointed us towards determinables for this reason, many questions remain. What determinables should we be realists about? How do determinables generate facts about modality? How does this fit the dispositional essentialist framework? Finally, after making room for determinables within Dispositional Essentialism, we are left with the question of what their role is and what the relationship between determinates and determinables is on this view. I will address these issues in the remainder of this chapter in order to give the most comprehensive account of the interplay between determinates and determinables within a Dispositional Essentialism which can truly account for laws.

3.4 Which determinables?

By endorsing realism about determinable properties, Dispositional Essentialism can account for determinable laws as supervening on determinable properties. Recall the core of Dispositional Essentialism is that dispositional properties give rise to laws. In other words, at least some, if not all, properties have dispositional essences. This means that they are the property they are in virtue of their disposition or propensity towards a certain manifestation in the world. Properties are what they are in virtue of their

modality. They have internal modal relations to further properties. These relations make for laws of nature.

My proposal is that we accept determinable properties and allow these to account for determinable laws in the way dispositional properties account for laws within Dispositional Essentialism. This requires little departure from Bird's type of framework. After all, all this requires is the move he was already making – for laws to supervene on properties. The only difference is the shift in generality from determinate laws and properties to determinable laws and properties. It is even compatible with traditional dispositional essentialist readings where properties are universals that get their essence via their relations to further universals. It is entirely in keeping with Dispositional Essentialism that if determinable properties existed, they would have modal relations to further determinable properties. These relations are laws of nature. Further, these laws would have to be determinable since they relate determinables. If we accept ontological determinable properties there is no more mystery to determinable laws supervening on them than there is to determinate laws supervening on determinate properties.

I have made my view of the role of determinables clear. In the rest of this chapter I will look at issues for this view and how to flesh out the relationship between determinates and determinables. For now, in this section, I look at what determinables we should be realists about so we can move on to tougher questions.

One issue that may strike the reader is that what counts as a determinable or a determinate differs contextually. While "colour" is the determinable of "red" the determinate; "red" is the determinable of the determinate "crimson". So, it can be confusing which determinables we ought to be realists about. On the other hand, we do have reason to think that determinables "bottom out" and "top out". By this I mean that there may be super-determinates which are maximally specific and so are not determinables of anything. At the same time, there may be superdeterminables which do not fall under any other determinables.[6]

In his paper *Determinables as Universals* Ingvar Johansson (2000) argues that we should accept certain determinables into our ontology – superdeterminables (although he did not call them that). He claimed that such a determinable was identified by the

[6] Here I set aside the issue of whether they can be grouped under the determinable "determinable" or the determinable "super-determinable" or "property".

fact that all other properties are either (a) its determinates or (b) separated from it by a "gap". A gap is a total lack of resemblance between determinates, as is the case with colour, shape and volume. Particular colours, shapes or volumes can always be linked by a chain of intermediate colours, shapes or volumes. However, colour (whether generally or a particular shade) does not more closely resemble shape or volume (whether generally or any particular shape or volume) (Ibid, p. 108).

Another way of conceptualising the gap between superdeterminables comes from Funkhouser. Again, for Funkhouser, determinates and determinables are fleshed out in terms of determination dimensions. The determinable red, for instance, combines a particular region of the determination dimensions of brightness, hue and saturation. Thus, for Funkhouser, a superdeterminate will be a maximally determinate point in these determination dimensions. So, for instance, a specific shade of red with a precise brightness, hue and saturation. The superdeterminable would be the most general possible combination of determination dimensions. In this case, colour would be a superdeterminable as it is maximally unspecific regarding hue, saturation and brightness.

It does seem inevitable that there will be certain superdeterminates. However, I doubt that the answer to what determinables we should be realists about is 'superdeterminables like shape, volume and colour'. Even their superdeterminates (like crimson or perfectly round) are prime candidates for reduction to other properties. Colour, for instance, may be reducible to the wavelength of light or the reflective properties of surfaces (and their interaction with our optical system). I think we should base what determinables we are realists about on other considerations like explanatory value. These considerations may turn out to only favour superdeterminables, however we should allow for the possibility that they give an important role to some "intermediate" determinables (determinables which are determinates of something else).

In my view, being realists about the minimum sufficient determinables needed to account for the laws of nature is the way to go.[7] This strategy is reminiscent of David Lewis's strategy of using science as a guide to find the sparse or fundamental properties on which all else supervenes (2006). This keeps our ontology as austere as a realist ontology can be while allowing us to account for functional or determinable laws – the

[7] Here I am assuming that there is only one answer to ontological questions, setting arguments for scientific pluralism aside.

most important kind in physics and in our navigation of everyday life. Given that which laws of nature exist is an empirical matter, "what determinables should I accept into my ontology?" will be an empirical question too.

A caveat: of course there are always competing explanations. Indeed, there will still be competing explanations of laws which do not involve determinables at all. However, for the reasons given above, these seem unsatisfactory. They may be more parsimonious, but they don't give a unified explanation of determinable laws. By making what determinables exist an empirical matter, I leave the issue of which combinations are most explanatorily satisfactory open. A minimal ontology must be balanced with explanatory success. Addressing exactly how this balancing act works out - comparing different groups of determinables and how they account for all laws of nature - is most definitely beyond the scope of this work.

3.5 Complex properties and Dispositional Essentialism

Like many views in philosophy, there may be as many kinds of Dispositional Essentialism as there are dispositional essentialists. Some ideas are core to the view. To be a dispositional essentialist you must believe in dispositional properties. Further, dispositional properties are responsible for the lawfulness of nature. However, there are many ways of fleshing this out. In particular, we will be concerned with questions like whether those properties are single-track, multi-track, determinate or determinable. While the Bird-type view that only single-track properties are fundamental may be the best known, it is not the only contender - other dispositional essentialists allow for more complex dispositions.

Earlier we saw that Bird argues that fundamental dispositional properties are single-track. Here a single-track property is a property with a single stimulus-manifestation condition. Single-track properties are opposed to multi-track properties which have more than one stimulus-manifestation condition. His reasoning for this is that multi-track properties seem like conflations of multiple single-track properties. However, other dispositional essentialists have conceptualised dispositions differently. For instance, Brian Ellis (2001) speaks of dispositional properties supervening on other properties suggesting that higher-level properties may be legitimate. More to the point,

Stephen Mumford describes properties as power-clusters, allowing for the possibility of multiple-powered dispositions (2004). Vetter goes further to argue that all dispositions are fundamentally multi-track (2015).

Mumford says that: "The view of properties I [he] find most attractive is one in which they are natural clusters of, and exhausted by, powers" (2004, p. 170). He does not go on to explain exactly how that cluster works but he makes it clear that there is no ontological distance between properties and powers. It is not that properties *have* powers; properties *are* clusters of powers. If a property only had one power, it would presumably be identical with that power. Mumford addresses the issue of whether a property can have more than one power. He says the following:

> "Do the clusters that constitute properties always contain many powers? Could there be a property that had its identity fixed by a single power? Either option is consistent with the general realist lawless metaphysic being developed [in his book] and there could be a mixture in which some clusters of powers are complex and some simple." (2004, p. 172)

Mumford claims that properties having multiple powers, which would require them to be multi-track, is consistent with Dispositional Essentialism. However, he does not go as far as to advocate them. I have been arguing for incorporating determinable properties into our ontology as it goes a long way to solving the problems Dispositional Essentialism faces accounting for functional laws. I must consider how the notion of single-track and multi-track properties, single power and many-power properties, and determinate and determinable properties relate.

On the face of it, Mumford's single power properties map onto Bird's single-track properties, Mumford's many-power properties map onto Bird's multi-track properties. Further, single power properties (Mumford) or single-track properties (Bird) will be maximally determinate properties. Many-power properties (Mumford) and multi-track properties (Bird) will be determinable in the sense that they are multiply realisable. This is too quick.

Let's say we have a property S which has one power T. The fact that S only has one power – T – does not imply that S is a single-track property. T could be multi-track itself. The only way that having a single power requires the property to be single-track

is if we assume that each power will be single-track i.e. will have a single stimulus-manifestation condition. However, this has not been shown. To see this, Mumford believes that properties like spin, mass and charge are good examples of single power, fundamental properties (2004, p. 172). At the same time, Bird argues that mass is not single-track (and hence may not be fundamental) see below:

> "In classical physics mass is (i) a fundamental property, and (ii) associated with two dispositions, one inertial and one gravitational. The latter makes classical mass a multi-track disposition, i.e., a disposition that relates multiplicity of stimuli and manifestations. Indeed… it is an impure disposition, one which does not fit the schema: D is the disposition to manifest ($M_1 \vee M_2 \vee M_3 \vee \ldots$) in response to stimulus ($S_1 \vee S_2 \vee S_3 \vee \ldots$). There I argued that impure dispositions cannot be fundamental. It seems odd that a fundamental property should both yield manifestation M_1 in response to stimulus S_1 and also manifestation M_2 in response to stimulus S_2. That looks like a conjunction of propositions, which does not conform to the schema, and does not seem fundamental at all. It would appear that such a property, if genuinely a single property, would be a non-fundamental property" (Bird, 2007, p. 215)

I will not take sides on the fundamentality of mass. I leave that to science and indeed propose that we let empirical data shed light on which properties are fundamental. I do not share Bird's view that all fundamental properties must be single-track. As a result, the idea that mass is multi-track is not of much concern to me. I simply use this to illustrate the strength of Bird's conviction. However, on my view, it is too strong a claim to say *a priori* that all fundamental dispositions must have a single stimulus-manifestation condition. Especially given that science is not corroborating that story. The properties science is built on and, indeed, the ones that are of interest to it (e.g. mass or charge) are richer and more complex than that.

Bird insists that fundamental dispositions are single-track. Mumford allows for the possibility of dispositions with multiple powers however, he does not actively advocate them. However, Vetter actively advocates the complexity of dispositions. According to her, dispositions are inevitably multi-track. She rejects the conditional analysis of dispositions on the basis that it relies on an over-simplified view of dispositions according to which they have simple stimulus and manifestation conditions (2015).

Vetter (2015, p. 53) disambiguates between two ways or levels at which properties are complex or multi-track. This provides a much needed layer of nuance to the discussion. First, as we saw, determinables are complex or multi-track in the sense that they range over many possible determinate instantiations. Charge is determinable in the sense that it has many determinate charges (all magnitudes of charge). Further, any charged object will have a determinate charge.

However, Vetter points out that there is a more basic sense in which dispositions are multi-track. She argues that *each determinate property is irreducibly multi-track*. Each determinate instantiation encodes a myriad of single-track dispositions to slightly different manifestations, depending on what situation leads to their manifestation. Again, in the example of charge, even a maximally specific charge has a variety of stimuli (for every other possible charge it could encounter it will manifest slightly differently).

While determinates may be maximally specific and multi-track, this does *not* make them determinables which range over their single-track dispositions. This is because the maximally specific determinate has all the corresponding single-track dispositions at once. In Vetter's words "Having a determinable property entails having *one* of its determinates, to the exclusion of all others. Having the multi-track disposition electric charge, on the contrary, entails having *all* the corresponding single-track dispositions." (2015, p. 53) These single-track dispositions are not determinates because they are not mutually exclusive. It is not that charge X has only one disposition at a time to the exclusion of all others. Rather it has all those dispositions at once despite being maximally determinate.

Mumford and Vetter provide various avenues for properties to be complex. We saw that Mumford allows for properties which are clusters of more than one power. And Vetter allows for determinable properties like charge to have many determinate instantiations and for determinate properties to be infinitely multi-track. Vetter's work may make us question what Mumford means, pressing him for more detail. It leaves room for a property with one power to still have a multitude of dispositions, being irremediably multi-track in this way. This holds whether Mumford sees powers as determinates or determinables. After all, if Vetter is right, both determinate and determinable properties have many possible manifestations. The concept of power also seems flexible in this way i.e. open to many manifestations. Without more clarification 'power' may be

too flexible and ambiguous, confusing the debate. As a result, I set the term power aside for the sake of clarity.

I have shown that there are alternatives to Bird's neat picture where all modality is broken down to a fundamental level of maximally specific single-track dispositions. There is precedent for complexity in the dispositional world. Some even argue that this complexity is inevitable. I am happy to allow that maximally determinate properties have this complexity. However, this is a side note. My focus is on developing Dispositional Essentialism so that it can account for laws of nature. In the interest of accounting for functional laws I have proposed realism about determinables. This means allowing complexity at the higher-level Vetter talks about, allowing fundamental determinables into our ontology.

3.6 The relation between determinables and determinates

When I first introduced Dispositional Essentialism, I started with what many see as the status quo of the view: Bird's work. He believes that the fundamental level will be populated with single-track dispositions i.e. dispositions with a single stimulus-manifestation condition. We saw that there is tension between this view and the explanatory aims of Dispositional Essentialism to avoid views on which laws are mere regularities or brute facts about the universe. Dispositional essentialists aim to explain all modality from the bottom (properties) up. In my view, it is the assumption that they are explaining modality from *determinate* properties up that fuels the criticisms that Dispositional Essentialism cannot account for laws of nature.

In the previous section, we saw that some prominent dispositional essentialists allow room for complex properties. Mumford sees properties as power-clusters, allowing for properties to have various powers. Vetter argues that even maximally determinate properties have a multitude of dispositions, and so are irreducibly multi-track. Further, we saw in 3.3 that complex properties – determinables – can close the explanatory gap between modal properties and functional laws (Wilson, 1992). Determinables earn their keep by providing a kind of explanation for laws of nature which determinates cannot match.

If the only properties which exist are maximally determinate it is hard to explain why these determinates follow determinable or functional laws. Even if we see determinates through the power lens or the multi-track lens, they at most codify determinate laws. In other words, they only contain the modal information about that determinate, not about all other determinates of the determinable they belong to. Bottom-up explanations from determinate properties to determinables can't give a unified explanation of why they cohere in this way. Explaining Coulomb's law from the collection of determinate charges is unsatisfactory. It does not explain why the determinates resemble so closely, much less fall under a single equation. Determinables provide a much more satisfactory, or unifying, explanation. Rather than leaving the elegance of Coulomb's law as a regularity among many determinates, the behaviour of all the charges is explained by reference to the determinable charge. The law is explained by the very nature of charge.

I have argued for realism about determinables as a way out of Dispositional Essentialism's difficulty accounting for functional laws. If determinable properties are dispositional, they will give rise to laws of nature. These laws are determinable or functional as they relate determinable properties. This leaves open the question of how determinates fit into the picture. First, do we need them? Second, what is their ontological status compared to determinables? Third, what is the relationship between determinates and determinables on this modified Dispositional Essentialism?

Regarding the first concern, we definitely need determinates in our ontology. Determinables cannot ground all the facts or give us all the information about our world. As per d) determinables do not fix determinates. We cannot derive facts about which determinates exist from facts about determinables. For instance, knowing that a thing is coloured does not tell us what determinate colour that thing is. Rather, the reverse is true, if we know that a thing is scarlet we know that it has the determinable red and the determinable colour.

Wilson argued that those who assume determinates can explain all the facts about the world are assuming that all the facts to account for are non-modal (2012). As we saw, this is arguable as determinates are themselves modal in dispositional essentialism. Their essence is dispositional or modal. However, they only contain narrow, determinate, modality. They don't account for the wider laws of nature. In that sense, we need determinables to account for modality with a big M – the functional laws of nature that science discovers and that help us make sense of the world around us. The

flipside is that determinables cannot account for everything. Determinables give us the broad modal facts about reality but there is more to the story. In particular, there are still the facts about which determinates are instantiated to account for.

The second question regarded the ontological status of determinates compared to the fundamental determinables. There are at least two options in the literature. Wilson sees determinates and determinables as ontologically on par (2012) and Vetter argues that determinables may be more basic than determinables (2015).

I see determinates and determinables as ontologically on par. To use the God metaphor, she would have to create both determinates and determinables to create the world. Especially since, as we saw, they cannot explain or be reduced to each other. Both have important and unique roles to play. In my view, putting determinables first as Vetter does is an overcorrection. It seems to assume that determinables and determinates are competing for the same kind of explanation – modal explanation. But this is not what I see determinates as doing. These two have different roles. The determinates act as 'existential witnesses' to our world. They differentiate our universe from others with the same laws by saying what determinates are actually instantiated in our world. And, yes, if you are a dispositionalist they have some disposition and modality to them. However, we need the determinables to explain the determinable laws that the determinate laws follow.[8] This brings us to the third question about the relationship between determinates and determinables.

Finally, what is the relationship between determinates and determinables on my view? I will start by looking at common explanations of the relationship between determinates and determinables and why they fail. To begin with, we have seen a few already: the subset view and the view that determinables are sets of determinates. These are not appropriate for my view because I take determinables to have their own separate and vital explanatory role.

Another possibility is that determinables govern determinates. However, on such a view, determinates lose their causal oomph. They would act as mandated by determinables according to some sort of governance relation. This to me places too great a distance

[8] In chapter 7 I will also consider whether they have some explanatory connection to each other, on the basis that they are clearly not entirely independent of each other. The dispositions of determinates are not entirely separate from those of their determinables for instance.

between determinates and determinables. Further, it pushes the problem a step back as now we need to account for why these determinates obey the same determinable.

Bigelow and Pargetter (1988) suggested determinables were second-order properties. So, for instance, red is a second-order property which a crimson thing has. Objects have first-order properties like crimson and scarlet and second-order ones like red. These second-order properties are conceptualised as functional roles. The mention of functional roles invokes the ideas of multiple realizability which are amply discussed in the literature. The idea being that various determinates can instantiate the functional property i.e. the determinable.

My view is somewhat different from the available options. It takes inspiration from Wilson (2012) and French's (2014) views that determinables are modal and determinates give us non-modal facts. Determinates are referred to as giving initial conditions and/or providing 'existential witness'. In other words, they say what magnitudes of the determinables are actually instantiated, allowing us to differentiate our world from others with the same laws. Determinables are modal properties and determinates are instantiations. Thus, for me relationship between determinables and determinates is not one of governance but of instantiation. Determinables do not govern determinates. Determinates *instantiate* determinables.

Determinates and determinables are not independent of each other, both are dispositional. On my view, determinate properties are the sort of properties which are actualised and which actualise determinables. They give us non-modal, concrete, information about our world. We need to pair non-modal facts with modal information to explain the trajectory of the world. A full explanation of the world and its modality must cover its lawfulness. Functional or determinable laws need accounting for or something is missing from the picture. This is where determinables come in. Determinable properties, as dispositions, have modal relations to further determinables. Those relations are high-level functional laws. This view has the benefit of explaining why different determinates follow the same determinables – they are instantiations of those abstract properties.

Another benefit of this view is that it helps avoid the overdetermination concern. In a sense, determinates are instantiations of limiting conditions of determinables. This could raise overdetermination worries. My response to these worries is reminiscent of

Shoemaker's given above - that determinates and determinables are not in causal competition. However, this is not simply because they contribute the same power to the causal story. In addition, there is a sense in which determinates and determinables have different roles which do not compete. We need both the high-level modal facts and non-modal facts to explain causation. The modal and non-modal facts do not compete. They complement each other. (For a more detailed response to the overdetermination concern see 7.4.1-7.4.3.)

3.7 The next move for Dispositional Essentialism

By showing that determinables are a necessary part of our fundamental ontology, that determinables ground facts that determinates do not, and that determinables are not reducible to their instances, we have a solid case for realism about determinables. This helps the dispositional essentialist respond to the first objection – that the laws of physics are functional or determinable. This problem disappears for Dispositional Essentialism if it allows laws to relate determinable properties. After all, if laws relate determinable properties, they will of course be determinable or functional themselves.

The second problem we saw for Dispositional Essentialism's account of laws is that the laws of physics do not fit the formalism Bird forwards. In particular, laws of physics are not of the type $\forall x((Px \wedge Sx) \rightarrow Mx)$ where P stands for any property, S for its stimulus and M its manifestation. Laws of physics are more complex than this. I do not fight Vetter (2012) on this point. In my view the dispositional essentialist would do well to distance themselves from Bird's position here – as I have tried to do. Dispositional Essentialism can benefit from being more flexible in terms of properties' dispositions, not mandating that properties only have a single stimulus and manifestation condition. Further, and as a result, dispositional essentialists ought to be flexible on what exactly the laws of nature will look like.

I do not think that we can *a priori* establish, as Bird hopes, that every property has a single stimulus-manifestation condition. Further, the *a posteriori* evidence (the laws of physics we have) does not favour this kind of neat view. In my view dispositional essentialists should be flexible and open to more complex patterns in nature. Properties

may have multiple powers (Mumford, 2004), they may be infinitely multi-track (Vetter, 2015) and they may relate to each other in a myriad of complex ways.

One final and dare I say bigger hurdle awaits the dispositional essentialist account of laws: the problem of global principles. In the next chapter, I will explain what global principles are, why they matter so much, why they are so problematic for Dispositional Essentialism, and how I think the dispositional essentialist ought to go about explaining them.

4. Accounting for Global Principles within Dispositional Essentialism

Dispositional Essentialism has difficulties accounting for laws. I have argued that a lot of the criticisms of Dispositional Essentialism stem from the assumption that it explains functional or determinable laws via *determinate* properties. I argued that if we accept determinable properties into our ontology this problem goes away. Functional or determinable laws relate determinable properties. However, the problems for Dispositional Essentialism are not over. A class of laws remains which dispositional essentialists really struggle to account for. I will call these global principles. Global principles are high-level laws like symmetry principles, conservation laws and the principle of least action. They are high-level because they apply to a wide range of properties, if not the whole world. As a result, it is hard to see how global principles can be accounted for via the dispositional essences of individual properties.

I start this chapter by explaining the difficulty global principles pose for Dispositional Essentialism. After, I will lay out various strategies Dispositional Essentialism can employ to account for global principles. I begin with the strategies in the existing literature. These have been criticised as *ad hoc* and explanatorily poor (Livanios, 2010). Then, I proceed to advance some novel strategies. I argue for my novel take on the basis that it has the explanatory advantages of the old strategies while avoiding the criticisms levelled against them. Showing that Dispositional Essentialism has a strong account of global principles sets the scene for the next chapters. In the next chapter, I bring the discussion of global principles out of the abstract by looking at case studies from physics. I look at how Dispositional Essentialism can account for conservation laws and the principle of least action. Afterwards, in chapter 6, I look at another theory which claims to have the same motivations as Dispositional Essentialism while doing a better job at accounting for laws (Ontic Structural Realism). Having a strong account of even the most elusive laws will help the dispositional essentialist position here.

4.1 The problem of global principles for Dispositional Essentialism

Thus far the laws we have been considering have been relatively simple. Laws like Coulomb's law or the law of gravitation are relatively simple because they are about

particular properties, in this case charge and mass. And, within the dispositional worldview, they are explicable in terms of the nature of those properties. That is, of course, not to say that those properties are simple in Bird's stronger sense. Recall that Bird argues that the fundamental properties would all be single-track dispositions with a single stimulus and manifestation. I have argued that this kind of simplicity is not realistic within Dispositional Essentialism as these properties are unable to ground functional laws which are determinable.

I have shown that there is precedent and thus room for complex properties within Dispositional Essentialism. Properties may have multiple powers, be determinable, or infinitely multi-track at the smallest level. I have argued that in addition to there being room for complex properties there is *need* for complex properties within Dispositional Essentialism. We must make room for determinable properties in our ontology to account for even the simplest laws of physics as these are functional or determinable. Determinable properties allow us to account for determinable laws. This is because the laws will follow from the dispositions of the properties. However, not all laws are so simple.

Accounting for regular laws, like Coulomb's law, via the dispositions of properties is relatively simple. This is because there are particular properties these laws are about (in this case charge). Thus, we can say that the dispositions of said properties give rise to the laws. However, not all laws are like this. There is a class of laws which resists this kind of explanation. These are the problem laws I refer to as global principles.

Roughly, global principles are higher-level laws rather than regular laws like Coulomb's law. They do not hold of individual objects and their properties, so they cannot tell us information like what force a massy object is exerting or what dispositions a charged object has. Rather, they hold of the whole universe. They appear to be laws the system follows which explain what happens at the local level rather than the reverse. So, if the universe conserves mass-energy that explains why any local loss of mass or energy will be paired with a gain somewhere else. The best-established global principles include symmetry laws, conservation laws and the principle of least action.

The generality of global principles makes them very difficult to explain from a dispositional essentialist standpoint. Dispositional essentialists want to explain laws by reference to individual properties. They aim to ground all modality from the bottom –

properties – up. Given that these laws operate at this higher-level they resist this kind of explanation. They are not easily tethered and grounded by a simple property.

Global principles are quite a diverse group of laws. For instance, the *principle of least action* states that, when in doubt about how a system evolved, the option which required the least action is the correct one. We can visualise least action as the shortest trajectory between two points, however this is not technically correct. Action is a technical term for the difference between kinetic and potential energy over time. When we want to decide how a system evolved, the principle of least action tells us that the trajectory which involved the least action occurred (Katzav, 2004; Smart & Thébault, 2015). *Symmetry laws* are closely tied to the concept of invariance. Symmetry laws outline what sort of transformations things can undergo without changing in other ways e.g. translation in space-time, spatial rotation. For instance, the speed of a train could change without affecting the laws of physics inside the train. Symmetry principles constrain which particles are able to exist leading to the prediction and discovery of the Higgs boson (French, 2014, p. 271). (I will not be focusing on symmetry principles except for where they reappear in connection to conservation laws in the following chapter). Finally, *conservation laws* regard the fact that certain physical quantities – e.g. mass-energy, angular momentum, momentum, number of leptons – remain the same over time. I will give a much more detailed analysis of these in the next chapter "Case studies in accounting for Global Principles: Conservation laws and the Principle of Least Action".

Global principles are quite different from each other. What unifies or distinguishes this group of laws is how high-level the laws are. They apply to many physical properties rather than being predicated of a single one. As they relate so many properties, they resist the kind of bottom-up explanation Dispositional Essentialism promises. A good solution to the global principles problem should be abstract enough to account for all global principles, remaining neutral on which of these principles are legitimate.

Dispositional essentialists have not done much work on accounting for global principles. When they have, their attempts have been ignored or criticised for being *ad hoc* and explanatorily poor (Livanios, 2010). I begin with the existing options, like the world-kind approach, before moving onto novel strategies. I will show that there are alternative frameworks for accounting for global principles which improve on the current ones.

4.2 Accounting for global principles within Dispositional Essentialism

As we have seen, Dispositional Essentialism has difficulty accounting for global principles. This difficulty is rooted in the fact that these principles are general, applying to many properties if not the whole world. This makes it difficult to give bottom-up explanations of them in terms of the dispositional essences of individual properties. Dispositional essentialists can and have employed different strategies to account for global principles. These strategies are meant to be abstract enough to account for all global principles. As such, they are not tied to any particular global principle, rather they are proposals for dealing with global principles generally. Broadly these strategies are:

(S1) Dismiss global principles as pseudo laws (Bird, 2007)
(S2) Find a core feature of the properties governed by global principles to ground the laws
(S3) Posit high-level entities whose high-level properties give rise to global principles
    (S3A) Natural-kinds, in particular the world-kind (Bigelow, Lierse, & Ellis, 1992)
    (S3B) Systems (Chakravartty, 2019)
(S4) Posit high-level properties which ground global principles, rejecting the existence of high-level entities which bear them
(S5) Posit high-level properties which ground global principles, whilst remaining agnostic about the existence of high-level entities which bear them

The first strategy (S1) is reductive or eliminative of global principles. In a small section of the concluding chapter *Nature's Metaphysics* (2007) Bird recognizes the fact that it is hard to explain conservation laws by reference to dispositions. In the absence of an explanation he suggests that global principles are not genuine laws. They are either meta-statements about laws or they are part of the background structure which science aims to eliminate (ibid, p. 214). So, for Bird, global principles are either dismissed or are to be explained away by future science. He says this because of his commitment to Dispositional Essentialism. Within Dispositional Essentialism laws stem from the dispositional essences of properties so there is "no room for further constraints" (Ibid). If global principles were genuine laws, they would present 'further constraints'. Thus, Bird sees global principles and Dispositional Essentialism as being at odds with each other.

As he is committed to Dispositional Essentialism, he concludes that these principles must not be genuine laws. If anything, he would say that they are meta-statements about the limits of regular laws.

Bird's dismissal of global principles is unconvincing. Global principles are crucial to current physics to the point that physicists take symmetry laws as fundamental in nature. Not only do these global principles have far ranging applications but they have proved incredibly fruitful. They constrain which particles are able to exist, famously allowing the prediction and discovery of the Higgs boson, mentioned above. In Cei and French's words "Given the significance of symmetries and conservation laws in modern physics, some might take the conclusion to this argument as a form of *reductio* of the whole dispositional essentialist enterprise." (2010, p. 6)

Bird's treatment of global principles as pseudo-laws is also unconvincing because he never gives an independent argument for it. He simply states that we should endorse this view because it fits better with Dispositional Essentialism. Given how well established and fruitful global principles are to contemporary science their dismissal warrants a strong argument. As a result, I focus on accounts which are not eliminative regarding global principles.

The non-reductive strategies for accounting for global principles within Dispositional Essentialism attempt to pin-point properties which could give rise to such high-level laws. The first (S2) is to single out an aspect of the many things affected by global principles which could explain them. For instance, we might suggest that physical quantities are conserved, so the property of "being a physical quantity" explains conservation. This suggestion fails because not all physical quantities are conserved. Quantities like velocity are not conserved while others like entropy increase. I set this strategy aside as we are unlikely to find a property which fits the bill. Global principles hold for a large group of heterogeneous things which seem to only have obedience to the principles in common.

The second non-reductive strategy (S3) is the most popular and polemic. This approach involves positing high-level entities whose high-level properties could give rise to global principles. The most famous example of this is given by John Bigelow, Brian Ellis and Caroline Lierse (1992). In their view, laws of nature are explained via natural kinds (S3A). Natural kinds have essential properties; these properties give rise to laws. They

argue that global principles like symmetry principles and conservation laws cannot be explained via natural kinds which are mere parts of the world. The difficulty can be seen in the case of conservation. Conservation only fully holds in physically closed systems and the world itself, in its entirety, is the only physically closed system in existence. So, conservation appears to hold of the whole world in its entirely. As a result, Bigelow, Ellis and Lierse postulated the world-kind hypothesis. According to this hypothesis, the world is a member of the world-kind. As a natural kind, the world-kind has essential properties which give rise to global principles like conservation laws.

Before I explain this view, a caveat. One could argue that all laws only hold in the world as a whole i.e. as a physically closed system. Take the law of gravity - there are never only two masses to consider. There is an infinite series of endless masses to consider if we want to calculate the true value of any force in existence. This could lead a reader to think that there is not really a difference between regular laws and global principles. However, global principles are different. We can calculate with certainty the force that two objects exert on each other. The value of this force is independent of the fact that these objects are subject to further forces (which can all be calculated with precision). It is only if we want to calculate the net force that we need to worry about all the forces in the universe. Even then, the net force is no more than the sum of the individual forces. Global principles cannot be explained so easily. In the case of conservation, we can see conservation by summing up all the e.g. mass-energy of the universe. However, the fact that that number never changes, that every loss of mass and/or energy will co-occur with a gain of mass and/or energy elsewhere needs explaining. If anything, these high-level principles seem to be explaining the local occurrences which only make sense within the wider picture. This is what makes global principles so interesting and challenging from a metaphysical point of view.

Back to Bigelow, Ellis and Lierse's world-kind hypothesis. They take the world-kind to bear the high-level dispositional properties needed to account for global principles. They are careful to say that their theory is an ontological one and not an epistemic one. They are laying out what they see as the metaphysical conditions necessary for global principles. "We do not claim to know for sure what the conservation laws are. But we do say that when we get them right, they will describe essential properties of the kind of world we live in." (1992, pp. 385-6) This view has the benefit of avoiding regularity views of global principles. This is because these principles are explained via one high-level property rather than multiple lower-level ones. For example, we can account for the

conservation of mass-energy via the nature of the world rather than via the nature of mass and energy. Further, this would help explain why the conservation of mass-energy only truly holds in the world as a whole. That said, this view is quite unpopular and widely criticised as we shall see soon.

Recently, Chakravartty has come up with another variant of this account (S3B). On his view systems have properties, those properties give rise to global principles (2019). Sticking to our previous example, the conservation of mass-energy can be explained via properties of physically closed systems. This explains why the conservation of mass-energy only truly holds within the physically closed system that is the universe, holding only approximately in experimental setups which approximate this closure. In my view, this rendition of (S3) is more successful than the natural-kinds one. This is because it is more ontologically neutral and less *ad hoc* than saying that global principles hold of the world in virtue of its membership to the natural world-kind.

The systems approach is more ontologically neutral than the natural kinds approach in two ways. It is more ontologically neutral in the sense that (i) there is a strong motivation from science to import the notion of systems. The scientific motivation for systems is independent of metaphysics which makes talk of them seem less *ad hoc*. (ii) the systems approach is not tied to a natural-kinds ontology. One can be a natural kinds advocate, undecided on natural kinds, or have a sparser ontology without natural kinds while accepting systems as entities in their own right. We can see the systems science talks about as groups of individuals tied together somehow – through properties or relations – and as individuals in their own right, possibly through the lens of emergence or as members of natural kinds. (More on the systems approach in the next section.)

I will forward two novel strategies which I believe improve on the existing strategies. They both posit high-level properties which ground global principles. However, the first denies the existence of high-level entities. The second carves a middle ground between (S3) and (S4) remaining neutral on the existence of high-level entities.

The first novel strategy I forward is (S4). This strategy posits high-level properties which ground global principles without positing high-level entities like the world-kind. It is worth noting that, in my view, these properties would be determinables. This is because, as I have argued in chapter 3, we need determinable properties in order to

account for functional laws. The same is true of global principles. So, this is not just compatible, but can be seen as an extension of the work I have done thus far.

The idea of positing high-level properties but no high-level entities that realise them has not yet been explored. However, it has a lot of promise. In the next section, I show that it can be argued for using the exact same evidence as (S3). However, it is more parsimonious than (S3) because it posits fewer entities to account for global principles. Roughly, this strategy works by allowing for collective properties. So, it allows for multiple objects to collectively instantiate a property the individual objects lack. This has the benefit of retaining the principle that properties need bearers, it is just that here the bearers are a plurality of things rather than a singular thing. To exemplify this, I will show how two electrons can individually have indeterminate spins but collectively have spin zero. By allowing multiple entities to collectively instantiate properties we do away with the need for high-level entities in our ontology.

Finally, I will forward (S5). High-level properties fit with a variety of metaphysical pictures, some involving high-level entities (S3), some not (S4). (S5) posits high-level properties but remains neutral on whether the objects which bear them are unified high-level objects or not. In other words, it is agnostic about high-level entities at least until evidence surfaces to show that there are indeed high-level entities. (S5) has a lot going for it. It benefits from more ontological neutrality than the systems approach (S3B) while retaining the parsimony of (S4).

4.3 Refining our account of global principles: kinds, systems, or ordinary objects

Dispositional essentialists are quite receptive to explaining global principles via properties of high-level entities like the world-kind or systems (S3). This is because, they are seen as the best if not only way to account for global principles within Dispositional Essentialism. However, those outside the Dispositional Essentialism fanclub are quick to criticise this approach which seems a fit farfetched (Livanios, 2010).

The complaints against Dispositional Essentialism's account of global principles are generally lodged at the world-kind approach (S3A). This is in part because, for a long time this was the only option on the table. The fear is that dispositional essentialists simply label any high-level laws which are hard to explain as derived from properties of

the world which it has in virtue of membership to the world-kind. How does the systems account improve on this approach?

Chakravartty proposes the notion of systems to solve Dispositional Essentialism's global principle problem. The idea is that these high-level entities have high-level properties which give rise to global principles. However, Chakravartty never explains what he means by systems. In fact, the following passage suggests that he uses the word 'system' to avoid metaphysical explanation: "On reflection, it is clear that the basic idea of the response suggested by Bigelow *et. al.* can be recast in terms that dispense with much of the metaphysical jargon. We experiment on and theorize about different kinds of systems" (2019, p. 13). I will return to the positive account of systems, but first I will look at what motivates this account.

4.3.1 Motivating the systems account

Chakravartty points out that it is not unusual to postulate properties at the system level in science. For instance, a biologist might speak of properties of cells or living organisms. However, talk of systems is perhaps most easily justified by entanglement in Quantum Mechanics. Explanations of this phenomenon involve attributing properties to quantum systems that cannot be explained by the properties of their parts.

When objects are entangled there are properties which can only be attributed to the entangled system, but not to its parts (the individual quantum objects). The properties of the individual quantum objects are not just unknown but indefinite. They are only acquired or fixed upon measurement. The standard example of this is a system of two electrons which are anticorrelated with regard to spin, with an overall spin of zero. When we measure the spin of the first electron we fix it and, in that same instant, we fix the spin of the second. The second electron has opposite spin to the first since their sum is zero. Strangely, when one electron is measured the spin of the other is instantly determined, even if they are on opposite ends of the universe.

The mysterious behaviour of entangled systems has led philosophers and physicists to think that quantum objects are nonseparable and that the quantum world is holistic (Healey, 1991; Teller, 1986; Schaffer, 2010). Broadly holism implies that the whole is more than the sum of its parts. The parts of a quantum system (the individual quantum objects) do not fully determine its properties if it is entangled with another quantum

object. This problem is all the more pressing given that entanglement is a widespread phenomenon rooted in the very foundations of Quantum Physics. To put its commonality in perspective Michael Esfeld says that "what has to be accounted for in quantum theory is not entanglement, but cases of the absence of entanglement, if there really are such cases" (2004, p. 604). Further, Jonathan Schaffer went as far as to use entanglement to argue for priority monism. On this view, there is only one object in existence – the world – with everything else being a proper part of it (2010).[9]

Chakravartty takes this to mean that a) systems exist and b) there are properties of systems which cannot be reduced to properties of their parts (2019, §3.2). By using scientific evidence for his systems approach Chakravartty can brush away the charge of being *ad hoc*. Positing systems is, arguably, no more *ad hoc* than scientists positing properties of entangled objects. Both are responding to the same situation where the data resists bottom-up explanation.

I will argue that the scientific evidence does not in fact mandate the existence of systems. What it does show is that there are high-level properties which cannot be attributed to an individual low-level object. So, where someone of Chakravartty's persuasion might say that a) systems exist and b) there are properties of systems which cannot reduce to their parts; I am agnostic on a). In my view, we can only be confident in b) there are high-level properties. However, first I will compare the systems and kinds approaches.

4.3.2 Systems vs kinds

Chakravartty clearly uses the term system to avoid metaphysical jargon and commitments. This way he can claim to be purely motivated by the scientific evidence – not metaphysical bias. This is supposed to do away with concerns of *ad hocness*. Additionally, this makes his view more ontologically neutral than the natural-kinds approach. This is because, the systems approach is compatible with the natural kinds ontology but not married to it.

[9] While I do not endorse Schaffer's view, Dispositional Essentialism is consistent with different views of what objects are fundamental and bear the dispositional properties that give rise to laws. Thus, one could endorse Dispositional Essentialism while thinking that there is one big object – the cosmos – and smaller objects are partial considerations of it.

There are various ways of answering the question "what is a system?". A philosopher of Brian Ellis's persuasion can read systems as natural kinds. However, this is not necessary. Dispositional essentialists hostile to natural kinds, or who endorse natural kinds but reject essentialism about them (Mumford, 2005) can still talk about systems. The scientific evidence of systems suffices to justify systems regardless of one's opinion on the natural kinds debate. We can see systems as groups of individuals tied together in some distinctive way, say by their properties or relations to one another. Another possibility is to see them as individuals in their own right through an emergence lens. The notion of 'systems' seems metaphysically open, compatible with multiple ontologies.

While the systems approach is more ontologically neutral than the natural-kinds approach it is not open to any ontology whatsoever. To fulfil their purpose in accounting for global principles within Dispositional Essentialism, systems will have to have properties. Further, these properties will not be held by the system's parts, or there would be no need to postulate the system in the first place. Thus, these properties will be 'basic' in the sense that they cannot be explained away by lower-level properties had by the system's parts. Further, they will need to have dispositional essences. This places limits on the ontological neutrality of the term "system". It will not be compatible with e.g. extreme nominalist views which deny the mind-independent existence of properties, regularity views of laws or categoricalist views which separate properties of systems from their nomic roles.

Recent debates on modelling and idealisation in the sciences provide fruitful options for understanding systems. Marco Nathan says that systems are idealised models (2015, p. 261). His view is that dispositions are often not properties of objects but of idealised models instead. He believes that this best explains why dispositions may often not manifest, to the point where they can even break with regularities. On his view, these dispositions hold due to properties of the microstructure of the entities in question. These properties may themselves be dispositional – so there may be fundamental dispositional properties - however high-level dispositions like fragility are not fundamental. For Nathan the properties of systems are not fundamental.

Before I discuss idealisation (which systems are idealised and what idealisation even means) I need to address the dispositional properties Nathan cites. I agree that properties like fragility are not fundamental. I find discussions using fragility as an example of high-level dispositions problematic because they often overlook other high-

level dispositions which are much better candidates for fundamentality. For instance, biological properties, mental properties or properties of entangled entities/systems are far harder to explain away.

Back to our main discussion, the first thing to note is that not all systems are idealised. The universe in its entirety is the only physically closed system in existence. As such, it is not idealised, sidestepping the tension between systems as idealised and real entities. Chakravartty argues that the universe may give rise to global principles in virtue of being a physically closed system (2019, §3.2). If systems which are physically closed give rise to certain global principles, we would expect these principles to hold for the universe as the only physically closed system in existence.

In addition to there only being one physically closed system – the universe – the global principles that we are concerned with here look like they would be explained by reference to it. The difficulty accounting for global principles within Dispositional Essentialism stems from their generality, and the fact that they seem to apply everywhere and to many different properties as seen in the example of the conservation where many properties e.g. momentum, angular momentum and mass-energy are conserved.

If we only need the system that is the universe to solve the problems laid out by global principles, Chakravartty's proposal will not be that different from Bigelow, Ellis and Lierse's (1992). The idea of a universe-system may be more ontologically neutral than the world-kind in the sense that the universe-system could be a kind or not. However, the universe-system may not seem like a vast improvement on the world-kind in terms of *ad hocness*.

On the surface the systems approach can improve on the world-kind approach by allowing for systems of various sizes, adding nuance to the debate. The systems approach may allow for smaller systems i.e. systems which are not identical with the universe. Instead, they would be proper subsets of the universe. However, these smaller systems will be less robust than the universe-system as they are not causally closed. It is here, in smaller systems, that the issue of idealisation occurs.

Smaller systems are idealised in a sense. However, this is not to say that they are not "real" entities or that they are mind-dependent. Smaller systems are simply idealised in

the sense that they are partial considerations. The notion of system is tied to that of focus – what accounts for certain phenomena. When scientists work with small-systems they highlight a few variables that are relevant and work with those despite their susceptibility to outside influences. So, for instance, we can study the solar system by considering only a certain region of spacetime. The spacetime region in question will be the most important for understanding the system's developments. After all, we can't possibly take everything in the universe into consideration every time we consider a system. Further, we focus on an appropriate scale, ignoring, say, the microphysical makeup of the planets despite the fact that the sum of the microphysical facts may explain the higher-level phenomena we study. To facilitate things systems are often idealised, meaning that outside influences are taken out of the picture altogether. This is despite the fact that other variables, or objects outside the system, could interfere.

In addition, smaller systems are not impenetrable and mutually exclusive. The variables which are decisive for one system may partially or entirely overlap with another. This overlap could be spatial, temporal or in terms of certain physical quantities (velocity, charge, etc.)

It seems mistaken to favour the systems view for allowing this nuance by allowing systems of different sizes. This is not just because, as we have seen, smaller systems get messy (or at least messier than the universe-system we need for global principles). Natural kinds advocates tend to see nature as riddled with kinds as Chakravartty may see nature riddled with systems. They are not limited to the world-kind. Further, they may claim kinds in response to the same evidence as Chakravartty uses for systems. In fact, they often do; both Chakravartty and natural-kind theorists use examples from biology for instance.

In the case of global principles, the universe-system may suffice. This avoids a lot of the metaphysical issues hinted at with smaller systems. However, when scrutinised, Chakravartty's system approach does not seem to have made much progress over the natural-kinds one. Any move Chakravartty makes the natural kinds theorist can mirror. This is hardly surprising considering they both create high-level entities in response to the same evidence. I concede that the systems approach is more ontologically neutral than the world-kind approach as it does not mandate a commitment to natural kinds. However, I will now show that there are more ontologically neutral and parsimonious options to consider.

4.3.3 A new approach - accounting for global principles without high-level entities

Ockham's razor tells us not to multiply entities beyond necessity. Philosophers prefer more parsimonious or simpler explanations all else equal. 'Beyond necessity' and 'all else equal' are key here. While simpler theories are preferred, more complex explanations are better if they compensate for their complexity in explanatory value. The aim is to keep one's ontology as sparse as possible without sacrificing explanation.

The views I forward in this section are more parsimonious than the accounts of global principles in the literature. The natural kinds and systems approaches postulated high-level *entities* whose high-level properties account for these principles. The approaches I turn to now do away with the first step. They do not postulate high-level entities. (S4) banishes high-level entities from its ontology altogether, whereas (S5) remains agnostic on whether these entities exist. I argue that global principles do not require high-level entities and that, as a result, we ought not to inflate our ontology to include them.

Within Dispositional Essentialism laws are accounted for via properties. Certain laws resist explanation in terms of regular properties. I called these global principles. In order to account for such high-level laws, Dispositional Essentialism needs high-level properties. Further, until now dispositional essentialists have posited high-level entities - such as the world kind or the causally closed system that is the universe - as bearers of these high-level properties. (S4) proposes we do away with these high-level entities, eliminating them from our ontology altogether. Importantly, this is not to say that (S4) requires bearer-less properties. Such a move would undoubtedly raise many eyebrows. After all, the very notion of properties seems to require something or things which have that property. Rather, my proposal is that ordinary objects can collectively bear the high-level properties needed to account for global principles.

Property-bearing is often assumed to be a one-to-one relation. In other words, for every token property there is a single object which bears it. This assumption fuels the postulation of world kinds and systems to account for global principles. However, the notion of collective properties breaks with this tradition (Cornell, 2017; Caves, 2018). Advocates of collective properties allow for property instantiation to be a one-to-many relation. They allow multiple objects to collectively bear a property.

Collective properties are not like distributive properties. A group has a distributive property if each of its members has said property. Collective properties are properties which individuals *jointly* possess. They are instantiated by the individuals plurally but not by the individuals on their own. There are many examples of this in both metaphysics and philosophy of science literature. One sort of example is that multiple people could jointly (but not individually) surround a building. Another is that seven things can jointly (but not individually) be seven. If you allow for the possibility of gunk (infinitely divisible substance) you allow complex objects to instantiate properties. Whether you take that to involve collective properties will depend on whether you see the parts of those objects as objects or not. While there are many examples of collective properties, I will focus on the entanglement example as it is the go-to example when arguing for high-level entities (Chakravartty, 2019).

We saw that two electrons may jointly have spin zero, but not have definite individual spins. In this case the two electrons can be said to share the superimposed property of <up,down>+<down,up> spin. In other words, it is indeterminate which has spin up and which has spin down until a measurement is made.[10] The individual electrons do not have this superimposed property because this property makes reference to the other electron. We know that their joint spin is zero. However, the individual electrons do not have a fixed spin in this state. They only acquire a fixed spin upon measurement, at which point the entanglement is broken.

The entanglement example nicely illustrates the ambiguities lurking behind talk of systems and their properties. Talk of two electrons and the entangled system are used interchangeably in the literature. As a result, it is not clear whether entangled systems bear properties *qua* objects in their own right (one-to-one instantiation) or whether the objects which are entangled bear collective properties (many-to-one instantiation). I will give some reasons for preferring the latter reading.

One reason to think that we have a collective property in the two-electron example is that electrons are more than entangled muddles. They each have individual properties. So, each electron will have its own mass and charge. This suggests that they are very much distinct objects. How else could they have separate properties? Of course, we could include both electron 1, electron 2, and the entangled system 1+2 in our ontology.

[10] I am assuming a collapse interpretation of Quantum Mechanics.

However, this would inflate our ontology, bringing me to the second reason for favouring the collective property view.

By allowing for collective properties we do away with the need for high-level entities. Recall that dispositional essentialists only postulated high-level entities in order to explain high-level properties (and thus laws). Collective properties do away with the need for these high-level entities. The ordinary objects we already have in our ontology suffice. Ordinary objects bear the properties (and thus ground the laws) in question. Further, Ockham's razor tells us that we must prefer the simpler of two ontologies, all else equal. Hence (S4) is born.

A third point that can be raised in favour of collective properties is that postulating high-level entities can be highly problematic. There are examples where collective properties simply make more sense. This is easily seen in the case of number instantiation. Let's say we have seven objects. If we believe in the one-to-one property instantiation picture, seven things cannot instantiate the number seven. Rather, we are now committed to eight things. The seven things that existed already plus the plural object which instantiates seven. This seems clearly wrong (Caves, 2018). The mathematical case is particularly illustrative because it lands us in a paradox. Without collective properties, we need 8 things to instantiate 7, and 9 things to instantiate 8, which seems absurd. It is hard to judge if this kind of paradox is unique to mathematics or not. However, if we already have everything we need in our ontology to account for a property, why keep postulating more entities?

Global principles operate at such a high-level that entities as big as the world are postulated to ground them. This involves a sort of double counting. Our ontology contains all the objects in the world *qua* individuals and *qua* the world. However, it is possible that all the objects in the world collectively bear properties instead. This avoids double counting as we do not need a world-kind or universe-system in addition to everything else. (S4) points out that ordinary objects can band together to collectively share any property which the world-kind can.

The second, novel strategy is to allow for high-level properties but remain agnostic on whether there are high-level entities (S5). High-level properties are compatible with multiple metaphysical frameworks. So far it has been assumed that they require high-level objects which bear those properties i.e. natural kinds or systems. However, there is

also the option of not postulating these high-level entities at all. Instead, high-level properties might be shared properties in the sense that two or more objects share them. They might also be seen as emergent properties which supervene on various objects. In sum, it is not clear that a commitment to high-level properties mandates a commitment to high-level entities.

I have sympathy for the (S5) approach of remaining neutral. We cannot rule out future evidence to the effect that high-level entities exist. However, I favour (S4). I argued that we do not have sufficient evidence to posit high-level entities to account for global laws. This is doubly damning for high-level entities when paired with parsimony concerns. Ockham's razor tells us that we ought not to inflate our ontology unless we have very good reason to do so. In the absence of "good reason" my ontology remains high-level-entity-free.

4.3.4 Collective properties, emergence and fundamentality

Accounting for global principles within Dispositional Essentialism requires high-level properties. Until now, it was assumed that these high-level properties require high-level entities to bear them, such as the world-kind or universe-system (S3). In the previous section I argued that we could skip the last step. There is no need for these high-level entities. I argued that ordinary objects can come together to collectively bear any high-level property the world-kind or universe-system was posited to bear. In this section I will consider the counter-position. In particular, I will look at Heil's case that high-level properties require a high-level entity to bear them (2012). I will show that his arguments do not apply to the kinds of properties needed to account for global principles and fail to provide an alternative account of how these principles come to be.

It is worth noting that Heil's views are crouched in emergence terms. Definitions of emergence vary. Broadly, emergence involves an addition of being. Let's say property X occurs when entities A, B and C and their properties A', B' and C' interact. If X is emergent it may be caused by A', B' and C' but it is not reducible to A', B' and C'. X presents something novel, an addition of being. Our ontology is incomplete if it does not contain X in addition to A', B' and C'. I am not taking sides on the emergence debate here as that is beyond the scope of the thesis and unnecessary for my argument. I can simply import Heil's criticisms of emergence to my collective properties and respond where they apply. Given that Heil's position is within the emergence language and

debate, and the fact that he would probably see my collective properties as emergent anyway, I will be using that language here too. I will show that these criticisms do not apply to the properties needed to account for global principles for various reasons.

4.3.4.1 Heil's view

Much of the emergence literature is hostile to the approach to global principles I have forwarded in this chapter. The emergence debate is dominated by emergent properties. The issue stems from emergent individuals. Some explicitly argue that emergent properties require emergent individuals (Jacobs and O'Connor, 2003; Heil, 2012).

Right on page 1 of his book, Heil promises a metaphysics that "stems, not from a nuanced analysis of talk about the universe, but from repeated head-on confrontations with the universe." (2012) Instead of using linguistic tradition and conceptual analysis to arrive at metaphysical truths, he proposes we look at the world and draw our metaphysics from what we observe. Yet he has some basic metaphysical concepts and categories through which he interprets the world. These arguably bias his views.

Heil has a traditional substance-property ontology. On his view, substances are basic entities. They have no substantial parts i.e. no parts which are themselves substances. Further, properties are ways substances are. No substance can be no way at all. Further, properties require bearers. Let me explicitly state that I am not arguing with the fact that properties require bearers. The issue is that he states *a priori* that the bearers must be single simple substances. In other words, for every token fundamental property there will be a fundamental substance, and vice versa. This follows mainly from his definition of substances. Substances are bearers of properties (2012, chapter 1). More to the point, they are also defined in terms of independence (ibid, chapter 3). Following Descartes and Spinoza, Heil sees substances as necessarily independent from each other. This prevents two substances from sharing a property, so to speak.

Heil is mostly averse to emergence. However, he claims that if and when there is a truly emergent property it will require an emergent substance as its bearer. According to him, this follows by the historical definitions of property and substances (dating back to Descartes and Spinoza). By definition, a property is a property of a substance – no property can exist without a substance to bear it. Substances are bearers of properties. Substances cannot have substantial parts. It is worth noting, however, that this is very

much up for debate. There are intuitions going in both directions and, as we saw in the previous section, there is fruitful work being done to show the possibility of high-level properties being collectively instantiated. However, it is not just the controversy that is a problem for Heil's conclusion.

The moral of Heil's introduction is that we ought not draw radical metaphysical claims based on linguistic tradition or conceptual analysis alone. That goes against the aims of the book. However, Alyssa Ney points out that "What all of this looks like is a metaphysical investigation of our concepts, albeit of a form that isn't afraid to end up with fairly revisionary claims. We start from our concepts, of substance and property, and follow them where they lead." (2014, p. 881) Historical definitions aside, let's look at the empirical arguments Heil gives for his theory. These aim to show that simple substances and simple properties are all we need to explain the phenomena we see.

Limiting our ontology to simple substances and simple properties does not prevent us from talking about complex objects and their apparent properties. Heil makes a point of saying that he can still talk about tomatoes and their being spherical and red. In fact, his views on complex objects help explain why his ontology is so sparse. He argues that red and spherical are derived from the properties of the simple substances which compose the tomato. Thus, there is no addition of being in the case of the tomato's redness and spherical shape. Heil's anti-emergent views span the whole of the "special sciences".

Heil believes that these sciences are tracking real regularities, however he says this does not warrant the ontological drama of emergence. In his words "None of this calls for ontological drama. … You can fairly speak of levels of description, taxonomic levels, levels of explanation, levels of complexity and organization, but it would be a mistake of a fundamental sort to imagine that such talk requires us to posit levels of being." (2012, p. 194) Heil strikes an odd balance between allowing for emergent descriptions of the world while resisting an emergent ontology.

According to Heil, special sciences make true and irreducible statements. However, he is quick to differentiate between the truth of these statements and their truth-makers. In his view, just because we can say true things about macro-entities like volcanos or organisms, does not mean that these statements have macro-entities as truthmakers. In his view, fundamental physics serves as truth-makers for the true claims of all sciences.

These claims are true because of the fundamental physics, not because there is any real addition of being.

It is worth noting that, despite his hostility to emergence in the special sciences, Heil accepts that emergence occurs. All the examples he gives of possible emergence are from physics. The only clear-cut example of emergence he mentions is the example of when two particles collide to form a new kind of particle, with the first particles being annihilated (2012, pp. 30-31). When faced with the problem of entanglement, he keeps an open mind. He does not concede emergence because he remains neutral on the correct interpretation of Quantum Mechanics. However, he says that if the whole world turned out to be entangled we would have a monist world. Here, by monist, I mean a world with just one substance – the world itself. Everything else would be proper parts of the world – the only true fundamental substance (Schaffer 2010; Heil, 2012, p. 47). This is the view whereby the whole world is a fundamental entangled object with fundamental properties. He would favour this view because of his understanding of the property-substance relationship.

Heil endorses the primacy of physics. He embraces the view that fundamental physics provides the truthmakers for every other science. He rejects a levelled view of reality, where there are high-level properties and substances. He is willing to accept that special sciences make irreducible claims, nonetheless these do not present a new level of reality. Their statements are true because of the physics. Naturally, when he talks about emergence, the only examples he is willing to concede come from fundamental physics (– a point that I will soon use for the benefit of my theory!)

In sum: Heil proposes an ontology of simple substances and their properties. He admits of emergent descriptions in the special sciences but shies away from an emergent ontology. Naturally, he only accepts emergence at that most fundamental level. In his view everything is explicable by that lower level. This does not shake my view for various reasons.

4.3.4.2 Responding to Heil

The assumption that high-level properties require high-level entities is also clear in the dispositional essentialist literature. Recall the existing strategies for accounting for global principles. First, there is the world-kind hypothesis. According to this hypothesis

we need global, world-level properties to account for global principles. Additionally, we need global, world-level entities to bear those properties. A natural world-kind, of which our world is a member, is immediately postulated to explain how our world could bear such a property. Similarly, Chakravartty posits systems as bearers of high-level properties. Setting aside the issue of whether these philosophers see this as emergence or not, they clearly feel the need to postulate high-level entities to bear their high-level properties. Before I tackle this issue a caveat.

I argued that we can indeed have high-level properties without high-level bearers. I did this via the notion of collective properties. Collective properties are not to be confused with emergent properties. Collective properties are properties instantiated by multiple objects. These may or may not be emergent. Take the case of a group of people who jointly surround a building. This property could be reduced to the properties of the individuals (the spatial locations of the individuals). That said, the property of being alive, conscious and/or entangled seem like ideal candidates for both being a) collective and b) emergent.[11] The properties which explain global principles are not reducible to the properties of their parts either. Whether or not that makes them emergent is a question for another time.

In the global principles literature, the need for high-level irreducible properties is assumed. What is up for debate is whether those properties require high-level bearers or not. I take those who argue that they do to be against collective emergent properties. This is because, in their view, any emergent property will be had by an emergent individual, not multiple individuals. If this were the case the motivation for (S4) and (S5) would be undercut. How can we respond to philosophers like Heil who say that these properties require a single substance to bear them?

First, in all of Heil's examples of seemingly emergent properties which are realised by fundamental entities and their properties, there is no mention of the kind of property that would ground a global principle. He never mentions the global principles we have been grappling with in this chapter. Conservation laws, symmetry principles or the principle of least action are left out of the picture altogether. Yet he is a realist about dispositions, so the problem of global principles is a problem for his view too. If he has a hypothesis about how these can be explained by simple substances and their properties,

[11] See Emergence for Nihilists (Caves, 2018) and Mereological Nihilism and the Problem of Emergence (Cornell, 2017).

he hasn't given it. For whatever reason, global principles do not seem to have occurred to him at all. As we have seen, global principles are problematic exactly because they resist bottom-up explanation. They involve many different properties, so they simply cannot be explained via the nature of individual properties. Further, these principles are considered fundamental to current physics, so they really ought to be addressed and consistent with our ontology.

Secondly, and more problematically for Heil, global principles are considered fundamental to physics. That would appear to put them in the "fundamental physics" category, not in the "special sciences" category Heil takes issue with. While he takes special sciences to be translatable or reducible by fundamental physical entities and properties, the same sort of explanation cannot be given for global principles as they are already fundamental physics. The fact that global principles are fundamental physical laws and not dealt with is problematic for Heil. He takes fundamental physics to be, well, fundamental. And he seems willing to accept emergence if and only if it is within fundamental physics. Yet here we have high-level irreducible phenomena occurring in fundamental physics and he doesn't mention it at all.

How can Heil deal with global principles? Let's say Heil accepts that global principles are emergent. Recall his commitment to every substance having a property and vice-versa. This commitment leads him to the view that every emergent property will require an emergent entity. Thus, he would need a world/universe level entity. He himself suggests that if entanglement has the holistic consequences hypothesised we are left with a kind of Monism (2012, p. 46). Here he references Spinoza's one substance and Schaffer's work on priority monism to back him up. Thus, I take it that were Heil to be persuaded of high-level properties like the ones proposed he would advocate for a position like (S3) where the world or universe is an entity with properties that ground global laws. Except he would take it further, to where the world is the only substance in existence.

If fundamental properties require fundamental substances, we are pushed towards accounting for global principles via a global entity (S3). The search for an entity large enough to bear the properties that ground global principles ends at the world- or universe-level. This is because the properties in question are so vast that many philosophers take these to be predicated of the entire world. Thus, our credence in global principles will lead us to postulate world-kinds or universe-systems.

Pluralism and Monism are forwarded as mutually exclusive and exhaustive options. Pluralism is the view that multiple objects at a certain level are fundamental. Monism is the view that there is only one fundamental object in existence. The latter is in vogue ever since Schaffer forwarded his priority monism. This is the hypothesis that only the universe is fundamental and everything else is a dependent part of it (2010). The issue here is that if the universe is a fundamental entity it is not clear how each of its parts can be fundamental. After all, if explanation ends at the fundamental level it will either bottom out (pluralism) or top out (monism).

In sum: it is often assumed that high-level properties require high-level realisers. This assumption has been pretty damning for Dispositional Essentialism. The difficulty this view faces in accounting for global principles came to light with the world-kind hypothesis, the idea of world-kinds puts some off the view. I think that this is premature. As I have shown, high-level properties and laws are compatible with multiple ontological frameworks, some of which involve high-level properties and some which do not. As for Heil's case that high-level properties can be reduced to lower-level ones, it simply does not apply here. Global principles are fundamental to physics. If you are a dispositionalist, those laws are grounded in fundamental properties – so those properties will be fundamental too. Many dispositional essentialists may be happy for a fundamental system or kind to bear the properties in question. For others, the option of those properties being collectively borne (as argued for earlier in this chapter) is a live option.

Conclusion:

In this chapter I tackled the final stumbling block for Dispositional Essentialism's account of laws: global principles. This has been a considerable problem for the view with little work done on solving the problem. The problem stems from the fact that Dispositional Essentialism grounds laws in properties. Given the generality of global principles, extremely high-level properties are needed to ground them. Save Bird's dismissal of global principles, the only attempts to explain global principles have involved postulating huge, all-encompassing entities to do the job. In particular, the world-kind or universe-system.

I have not disputed the idea that we need high-level properties to account for global principles within Dispositional Essentialism. What I have disputed is the need for the high-level entities like world-kinds or universe-systems. I did this by showing that global principles can only serve as conclusive evidence for high-level properties within Dispositional Essentialism. This is because, within Dispositional Essentialism, laws are accounted for via properties. Thus, global principles are compatible with multiple ontological frameworks.

I have argued that world-kinds and universe-systems are not necessary. They inflate and complicate our ontology to no explanatory benefit. High-level entities were postulated in response to the assumption that property instantiation is a one-to-one relationship whereby each token property is instantiated by a single object. I have shown that high-level properties are compatible with another picture which rejects this assumption and avoids high-level entities altogether. The idea is that property instantiation can be a many-to-one relation. Multiple objects can come together to bear a collective property. Further, this property can present a significant addition of being, being irreducible to the lower level.

Both the traditional approach and the collective property approach respond to the same evidence for high-level properties and laws. Further, I have shown that literature on high-level properties switches between talk of these properties being instantiated by groups of objects and by high-level objects. The key difference is that one postulates additional entities to explain the properties in question, the other does not. My goal has been to show that assumptions about property instantiation cut both ways. We are not forced to endorse high-level and potentially *ad hoc* entities. We have multiple frameworks to choose from. In the absence of evidence for world-entities or universe-systems, I propose we kick them out of our ontology. They are not doing any work regular objects couldn't already do.

5. Case studies: Conservation Laws and The Principle of Least Action

In Chapter 4 we saw that Dispositional Essentialism has difficulties accounting for global principles. Here global principles are high-level, general laws. These laws are hard to explain within a dispositionalist framework because they do not follow from the nature of a single property. Rather, they constrain many properties, if not the behaviour of the whole world. Given that in Dispositional Essentialism, laws are explained via the nature of properties, high-level laws require high-level properties. As a result, philosophers have hypothesised that there are world-kinds or universe-systems which bear global properties which ground these global principles (Bigelow, Ellis, Lierse, 1992; Ellis, 2001, 2004; Chakravartty, 2019). In chapter 4, I proposed we do away with these high-level entities, allowing global properties to be collectively instantiated by ordinary objects.

Until now the debate on global principles has been quite abstract. This is partially because the proposal is neutral on which global principles turn out to be fundamental. I provided a general recipe for accounting for global principles within Dispositional Essentialism, regardless of which global principles are fundamental. In this chapter I will consider the two most discussed global principles in the dispositional essentialist literature: conservation laws and the principle of least action. These are often raised in criticisms of Dispositional Essentialism's ability to account for laws. Not much work has been done on them, besides referring to the world-kind hypothesis. I will spell out the difficulties conservation laws and the principle of least action pose for Dispositional Essentialism. After, I will look at the options for accounting for these within Dispositional Essentialism. Further, I will contrast the traditional account with my novel, more parsimonious, hypothesis. This chapter allows us to put the abstract strategies laid out previously into practice. It shows how we can use the metaphysical tools at our disposal to account for global principles in practice.

5.1 Conservation Laws

Conservation laws have challenged dispositional essentialists for decades. They appear in the earliest debates (Bigelow, Ellis, Lierse, 1992) on the global principles problem and

have become the go-to example (Bird, 2007, p. 213; Livanios, 2010; Ellis, 2001). Conservation laws tell us that certain physical quantities are conserved. These include mass-energy, momentum, angular moment, number of leptons, etc. This is problematic because conservation laws do not seem to be written into the nature of the quantities conserved. Individual objects do not conserve these quantities. In fact, it hardly makes sense to talk about individual objects conserving a quantity. We cannot see conservation locally in the object. Rather, conserved quantities are approximately conserved in isolated systems, and perfectly conserved in the universe itself. It does not make sense to think of an individual object as conserving momentum. The object can lose momentum, transferring it to another object in the system it is embedded in. It is the system's momentum that is conserved. The same applies to all conserved quantities. They do not appear to be manifestations of local dispositions. Rather, they appear to be high-level facts which are constraining how instances of the quantity evolve.

Before I lay out the ways in which Dispositional Essentialism can account for conservation, a caveat. Conservation laws, symmetry laws and the Principle of Least Action are often spoken about as fundamental laws. However, there is a chance that they are not all fundamental. In fact, some philosophers argue that one is explicable in terms of the other. My proposal is neutral on which global principles are fundamental. I provide an abstract recipe for accounting for high-level laws. The case studies I use aim to show how we can apply these metaphysical tools to account for global laws in practice. I am neutral on which high-level laws are fundamental, so it is not a problem if the particular examples used turn out not to be fundamental. Nonetheless, it is important to appreciate the connection between symmetry laws and conservation laws.

Emmy Noether developed a theorem which showed that for every symmetry there was a mirroring conservation law. Her theorem shows e.g. that space translation symmetry is tied to the conservation of momentum, that rotation symmetry is tied to the conservation of angular momentum etc. (Livanios, 2010; Hanc, Tuleja, & Hancova, 2004). This makes sense if we think about symmetry laws as telling us how one thing can vary without affecting others. For instance, the speed of a train can vary without affecting the physics inside the train. Symmetry and conservation laws are both tied to invariance. Conservation laws show that certain quantities are always conserved, invariant under transformation.

Noether's theorem could be used to argue that symmetries explain conservation (Livanios, 2010) or vice versa. Further, it has even been suggested that this connects symmetries and conservation to the Principle of Least Action (Hanc, Tuleja, & Hancova, 2004). This highlights what is so unique about global principles. They give hint at a high-level – global – order to the world. We are still processing how best to translate this order into laws.

A detailed investigation of how global principles relate, and which global principles really need explaining is beyond the scope of this chapter. Much more work needs to be done to establish a pecking order of global principles and decide which ones are irreducible. I won't be concerned with whether symmetries explain conservation or vice versa. Rather, I will be using conservation laws (and then the principle of least action) as a case study to show how Dispositional Essentialism can account for global principles. Whatever the outcome, the link between conservation and symmetry is not a problem for the strategy I set out here. If symmetries turn out to explain conservation (or vice versa) so much the better for Dispositional Essentialism. Dispositional Essentialism would have one fewer global principle to account for. In addition, it seems likely that laying out the foundation for explaining one side of the symmetry-conservation dilemma would help shed light on the other. Regardless, until we know which global principles are irreducible it will serve Dispositional Essentialism well to be able to explain conservation laws and global principles generally.

5.1.1 Accounts of conservation laws within Dispositional Essentialism

There are at least three strategies for accounting for conservation laws within Dispositional Essentialism

a) Explain conservation away as the result of other non-global laws or properties
b) invoke a high-level entity to bear high-level properties that ground conservation laws
c) invoke collective properties which ground conservation laws

I argue that a) may be possible but is highly implausible. It leaves too much to be desired in terms of explanation. Further c) is preferable to b). Thus, we ought to favour c).

5.1.2 Accounting for conservation laws via ordinary laws or properties.

One strategy to account for conservation laws is to explain them away via non-global laws or properties. In this section I won't be concerned with explanations of conservation laws via symmetries. I set that debate aside earlier. I will not be taking sides on which global principles are most fundamental here. Rather, I look at what strategies we can employ to account for conservation laws directly via ordinary laws.

One way of accounting for conservation laws is to explain them via non-global properties or laws. I briefly mentioned this kind of strategy in the previous chapter. In particular, I mentioned that Bird, in the absence of an explanation for global principles, suggests that they are not genuine laws. They are either meta-statements about laws or they are part of the background structure which science aims to eliminate (Bird, 2007, p. 214). For Bird, global principles are either dismissible or will be explained away by future science. Further, we saw that he said this because he was committed to Dispositional Essentialism. Within Dispositional Essentialism laws stem from the dispositional essences of properties so there is "no room for further constraints" (Ibid). If global principles were genuine laws they would present "further constraints" so Bird rejects them. I argued that this is not really an argument (much less a *good* argument). However, I will attempt to construct an argument for accounting for conservation laws via non-global properties.

First, let's get clear on the difficulty posed by conservation. We can disambiguate between two issues here. These are not disambiguated in the literature but seem vital to understanding the real difficulty posed by conservation laws. The first is local, the second is global. At the local level, we are challenged to account for individual conservation laws (particularly mass-energy, as we will see below). At the global level, the dispositional essentialist cannot explain why so many different physical quantities are conserved: mass-energy, momentum, angular momentum, etc. I will show that the second problem is illegitimate. The dispositionalist cannot be expected to give a unified account of why so many physical quantities are conserved.

Prima facie the fact that conservation holds of so many different physical quantities is a problem for Dispositional Essentialism. Dispositional Essentialism aims to eradicate brute laws and explain all modality from the bottom-up based on the nature of properties. Yet, conservation holds of a large heterogeneous class of properties which

only seem to have conservation in common. The concern is that Dispositional Essentialism will leave the fact that all these physical quantities partake in conservation brute. So, Dispositional Essentialism will be left with a hodgepodge of individual conservation laws.

The difficulty accounting for conservation at this global level is not a problem for Dispositional Essentialism. Or at least, it is not a problem for Dispositional Essentialism in particular. This is because conservation is not a unified phenomenon in the first place. The conservation of these physical quantities does not fall under a single unified law (as far as we know) so there is no need to give a unified explanation of them. No physical theory offers a unified explanation for the conservation of mass-energy, momentum, angular momentum, etc.

Expecting a global account of conservation would set the bar too high for Dispositional Essentialism. By making it clear that all theories are left with a hodgepodge of conservation laws the expectations of what Dispositional Essentialism must do to account for them changes. There is no single conservation phenomenon to account for. Thus, the dispositional essentialist need not explain why these quantities share in conservation. Instead, the dispositional essentialist is free to account for conservation laws on a case by case basis which fits her theory best.

The fact that conservation is a collection of individual laws, rather than a unified phenomenon, arguably calls the status of conservation as global principles into question. What makes the individual conservation laws global principles? Global principles are supposed to be more general laws than regular laws like Coulomb's law, resisting bottom-up explanation in terms of individual properties. The question is whether the individual conservation laws will be like this. And, if not, was Bird right all along in denying the legitimacy of global principles? I will show that he was not.

The greatest challenge to accounting for conservation is not global, in the sense that it is not that so many physical quantities are conserved. Each individual conservation law resists bottom-up explanation. The first local obstacle to giving a bottom-up account of conservation laws regards the conservation of mass-energy. While other conservation laws appear to be about one property e.g. momentum, angular momentum, number of leptons, the conservation of mass-energy is not. Mass and energy are not individually conserved. They are jointly conserved.

The universe has a total amount of mass-energy, that amount never changes. It is conserved. That said, the amount of mass and the amount of energy of the universe could change. This is because mass can be converted into energy and vice versa. The first law of Thermodynamics tells us that energy can never be created or destroyed. The energy of a system cannot be lost. However, energy can be transformed into mass. There is a known metric for this conversion: Einstein's $E = mc^2$. Here E stands for energy, m for mass, c for the speed of light. This equation tells us that energy equals mass times the speed of light squared. If the energy of a system declines, there will be a suitable increase in mass and vice-versa.

The conservation of mass-energy presents a unique challenge to Dispositional Essentialism because it does not follow from the nature of a single property, in the way the conservation of momentum, angular momentum, number of leptons, etc. do. The conservation of mass-energy does not appear to follow from the nature of mass or energy individually. These two are jointly, not individually conserved. In other words, it is the sum of the two which must remain unchanged.

There are various possible ways Dispositional Essentialism can respond to the problem of the conservation of mass-energy. I work under the assumption that mass and energy are metaphysically distinct. I take this to be the majority view among experts (Flores, 2005). However, a philosopher keen on a bottom-up account of conservation could hedge their bets on an interpretation of quantum mechanics where mass and energy are somehow one. Alternatively, they could say that the conservation of mass-energy is special and demands a special treatment. However, all other conservation laws are best accounted for from the bottom up. They could argue that high-level properties are only postulated when necessary to explain data which resists explanation. The conservation of individual properties which are individually conserved does not require this kind of special explanation. As a result, these conservation laws do not seem to be part of the special class of global principles. I do not aim to settle the status of mass-energy here.

Mass-energy is just the tip of the iceberg when it comes to accounting for conservation. The problem of conservation is much broader than the problem of accounting for mass-energy. In the next section we will see that *all* conservation laws (not just the conservation of mass-energy!) stubbornly resist bottom-up explanation. As we will see, these laws do not apply to individual objects but of systems. So much that it hardly makes sense to ask of an individual object if it conserves momentum (etc.). Our

discussion will flag up what makes conservation laws generally different from regular laws (like Coulomb's law) and deserving of the title of global principles.

5.1.3 Global principles, World-kinds and universe-systems

In this section, I will look at key features of conservation laws which differentiate them from non-global laws. I look at the scope of conservation laws, their role as constraints and why they seem to be imposed from the top-down. These features discredit bottom-up accounts of conservation. This sets the scene for the discussion of top-down explanations of conservation laws. In this section, I will show how conservation laws led to the postulation of a world-kind hypothesis. In particular, the world-kind allows the world to bear global properties which explain this sort of global law. This then will allow me to introduce my own proposal for accounting for conservation laws in the next section.

Usually, we expect all objects with a certain disposition to manifest that disposition in like manner, given the right conditions. For instance, we expect all charged objects to interact according to Coulomb's law. This allows us to predict how instances of charged objects interact based on a simple equation. If conservation laws were just like non-global laws, we would expect this to be true for them also. Let's say momentum has the disposition to be conserved and that each object with momentum manifests that disposition. We would expect that each object would conserve its own momentum. However, this is not the case. Conservation laws (and global principles generally) are not observed at the bottom level in this way. Rather, they are observed in semi-isolated and isolated systems.

In order to see conservation laws in action we need to take a step back and look at the big picture. It is not that individual objects conserve momentum. The whole system has a certain total quantity of momentum. That total quantity of momentum is conserved. Conservation is perfect within the universe as the only perfectly isolated or physically closed system in existence. However, it can also be observed in laboratory conditions of semi-isolation, where we try to limit the variables at play.

The fact that conservation is best seen from above does not mean that it has no bearing on non-global events. Conservation laws constrain what can and cannot happen. No event can occur which would alter the total amount of mass-energy, momentum,

angular-momentum, etc. of the universe. Marc Lange summarises the situation as follows:

> "It is not the case that momentum is conserved because electrical interactions conserve it, gravitational interactions conserve it, and so forth for each of the actual kinds of fundamental interactions. Rather, every actual kind of fundamental interaction conserves momentum for the same reason: that the law of momentum conservation requires it to do so. The conservation law limits the kinds of interactions there could have been, making a nonconservative interaction impossible." (2018, p. 16)

Prima facie, the dispositions of objects allow for many possible interactions. Many of these will run contrary to conservation laws. Conservation laws appear to act as constraints because they do not allow any interaction to occur which would alter the physical quantity of the system in question. Conservation laws here are the limiting factor, not the dispositions of the object.

The idea that conservation laws (and global principles generally) act as constraints is not new. Bigelow, Ellis and Lierse (1992) had already spotted this. They believed that once we really got to grips with fundamental laws there would be a knock-on effect. We would be able to predict what kind of particles and fields existed, along with their essences and how they would interact (p. 386). Indeed, global principles allowed Peter Higgs to predict the existence of the Higgs boson. A debate about the implications of knowing the final set of global principles is beyond the scope of this chapter. The important point to note is how conservation laws particularly, and global principles generally, act as high-level constraints as opposed to regular laws.[12]

Dispositional Essentialism aims to explain all modality from the bottom-up. In other words, it explains laws via dispositional properties. However, conservation laws resist this kind of explanation. They appear to reflect high-level regularities, so high-level that they only perfectly hold at the universe level. Conservation laws demanded a new kind of explanation. They were fertile ground for the creation of the world-kind hypothesis:

[12] I revisit the notion of global principles as constraints in my discussion of the principle of least action. There I address the dispositional structure of these laws and how they might be said to be non-causal.

> "Conservation laws are especially instructive, because they lend themselves exceedingly eagerly to our general analysis of laws. Conservation laws do look, on the face of things, like descriptions of essential properties of the world as a whole. It takes an effort to rewrite them in such a way that they sound as though they are describing correlations of some parts of the world with others." (Bigelow, Ellis, Lierse, 1992, p. 386)

I introduced the world-kind hypothesis in the previous chapter. To recap, this is a strategy for accounting for global principles via natural kinds. Natural kinds theorists claim that certain objects belong to natural kinds and have certain properties in virtue of their membership to those natural kinds. Biological examples - like "mammal", "plant" or "homo sapiens" - are popular. However, for the purpose of accounting for global principles, the world-kind is invoked. The idea is that the world is a member of a special kind too – the world-kind. The world has special high-level properties. These properties explain the high-level laws we witness. They follow naturally from the dispositional properties of the world itself.

The world-kind hypothesis is controversial. It was, for a long time, the only dispositional essentialist explanation for global principles. On the one hand it has some appeal. The world does seem like a rather unique kind of thing. It is the only physically isolated system in existence. Further, we see that this physically isolated system has an order to it, conserving various quantities, evolving in ways that require the least action (more on this in 5.2).

On the other hand, it seems rather *ad hoc* to inflate our ontology to include the world-kind when we find ourselves in a pinch to explain certain laws (Livanios, 2010). A less ontologically loaded way of seeing this is forwarded by Chakravartty (2019). As we saw, he replaced talk of world-kinds with talk of systems. He argues that there is good scientific evidence for the idea that systems have properties. The world is one big physically closed system, so it can have properties that ground global principles.

As we saw in the last chapter, in my view the success or otherwise of the systems approach boils down to one question: are systems ontologically robust or not. Given that all the literature on the matter presupposes that global properties require a global entity, and Chakravartty never challenges this assumption, I take it that he means that systems are entities. This being the case, the system approach is not that different from

the world-kinds approach. The system approach only presents a significant improvement on the world-kind approach if you are hostile to natural kinds. After all, the system approach still requires us to inflate our ontology to include a global object and global properties in order to account for global laws. In light of this, I argue for my new and more parsimonious account of conservation laws in the next section.

5.1.4 My account

Conservation laws act as top-down constrains on all interactions. They make sure that no interaction occurs which would alter the momentum, angular momentum, mass-energy, number of leptons, etc. of the world. Unable to account for these laws via non-global objects and properties, dispositional essentialists offered explanations in terms of the world-kind or universe-systems. In this section, I forward my alternative account of conservation laws via collective properties. I argue that it is a clear improvement on the previous models for explaining conservation laws.

The accounts of conservation in the literature share a similar structure. They start with the problem of a high-level law. They realise they need a high-level property to bear it. Then they postulate a high-level entity in order to bear that high-level property and ground the high-level laws. This high-level entity is global. It is either identical with the world as a member of the world-kind or as the all-encompassing physically closed system that is the universe. This has various issues. The first, which we explored in previous section, is that it seems farfetched to inflate our ontology to include a world-kind or universe-system in order to bear a high-level property that accounts for high-level laws. The second problem with a global entity approach stems from double counting. If we add a global entity to our ontology, our ontology contains both all individual objects and the totality of all those objects regarded as an object in its own right. The third and biggest issue is related.

The biggest issue for the accounts of conservation laws in the literature is that global entities are unnecessary. We do not need to double count. In the previous chapter I argued at length that the global entity approaches all rely on a common intuition: that property instantiation is a one-to-one relation. Each token property requires a single bearer. However, as we saw, there is no reason to think that property instantiation cannot be a one-to-many relation. In other words, it is possible that some properties are instantiated by multiple objects (Cornell, 2017; Caves, 2018).

There are many cases of possible high-level property instantiation. In biology, cells, organs and organisms all have properties (Chakravartty, 2019). In the philosophy of mind, mental properties require a detailed network of neurons. Further, this is what seems to be happening in the case of global principles like conservation. These seem to require a high-level property in order to ground them. Some would argue that if these properties are irreducible, there must be a single high-level bearer. This involves seeing the cell, organ, organism, mind or brain, and/or world as entities. However, I challenged this intuition. We can also see the collection of cells that make the organism, the collection of neurons that make up the brain, and the collection of entities that make up the universe, as jointly bearing the property in question. In my view this is no less sensical or intuitive. In fact, it is more intuitive than seeing these high-level objects as further entities.

My proposal is to do away with the global entity. We do not need it to explain conservation laws (or global principles generally). Ordinary objects can collectively bear any property the world-kind or universe-system was postulated to bear. Take the conservation of mass-energy. One way to explain this is to postulate a high-level entity – the world-kind or universe-system – which has a high-level property that grounds this law. My proposal is different.

Individual objects do not conserve mass-energy. An object could lose mass if the system it is embedded in gained energy. However, jointly, fundamental particles conserve mass-energy. My proposal is that the collection of relevant objects, in this case particles with mass and energy (or mass-energy if it turns out to be the same thing) jointly instantiate the property responsible for the conservation law. They jointly have a fixed amount of mass-energy to go around, they collectively instantiate properties (and thus conservation laws) that prevent any one of them from acting in such a way as to alter the sum off mass-energy.

All we need to account for global laws within Dispositional Essentialism are high-level properties. These high-level properties are compatible with both the existence and the non-existence of high-level entities. On my view, if global entities are unnecessary, we ought to do away with them. Ockham's razor tells us not to multiply entities beyond necessity. All else equal, our philosophical training tells us to prefer the more parsimonious explanation. I do not see why this should not apply here.

Conclusion:

Conservation laws resist bottom-up explanation. Rather, they seem to be top-down constraints on ordinary interactions. It is not that ordinary objects conserve momentum, angular momentum, mass-energy, number of leptons, etc. Rather, the world has a total quantity of these. This quantity is conserved. If the conservation of momentum is grounded in the dispositions of momentum, it will be grounded in the dispositions of the world's momentum. The world's disposition to conserve its total momentum constrains how ordinary objects interact. Ordinary objects cannot interact in ways which throw off the cosmic balance. They cannot interact in ways that alter the sum of certain quantities in the universe.

Conservation laws force the dispositional essentialist's hand. Unable to account for them from ordinary properties they must postulate high-level properties that ground these high-level laws. I do not take issue with this. However, until this point every attempt at postulating a high-level property has been accompanied by a global entity. This is what I take issue with. I have shown that these high-level entities are unnecessary. Further, I have argued that they are undesirable. They inflate our ontology to no explanatory benefit.

In sum: there are various ways of explaining conservation laws from a dispositional essentialist perspective. Conservation laws may be explicable in terms of symmetry laws, though I set this aside in this chapter. Additionally, conservation laws may be explained via high-level properties. These may be properties of a global kind or collective properties. In my view the latter – the collective property approach – is the best. However, it is worth emphasising the choices the dispositional essentialist has. Conservation laws are not an insurmountable challenge. They can be accounted for in various ways within the framework of Dispositional Essentialism.

5.2 The Principle of Least Action

The principle of least action is one of the most general, well-established, and philosophically controversial laws of nature. It allows us to calculate the trajectory of any object, or the evolution of any system via its initial and final positions. It stipulates that the trajectory which expends the least action is taken. Here action is the technical

term for the difference between kinetic and potential energy. The principle of least action, thus, shows that systems always evolve in such a way as to minimize action. Historically, the simplicity and generality of the principle of least action has led scientists to link it to hopes of a universal theory and philosophers to hypothesise that "nature is thrifty in all its interactions thanks to the perfection of God." (Terekhovich, 2018, p. 189) However, our focus is not on historic speculations but on how Dispositional Essentialism can accommodate this principle.

Dispositional Essentialism's ability to account for the principle of least action has been hotly debated (Katzav, 2004, 2005; Ellis, 2005; Smart and Thébault, 2015). The principle of least action is an architype global principle. It does not seem to follow from the dispositions of individual fundamental objects. *Prima facie*, there are many different trajectories an object can take, or many different ways a system can evolve. *Prima facie*, these are consistent with the dispositions of the objects in question. However, according to the principle of least action, no action-wasting moves are made. The trajectory which minimises action is favoured time and time again.

The principle of least action does not seem to be the manifestation of a particular property had by a particular class of objects. It is not like Coulomb's law which appears to be grounded in the dispositions of charge, dictating how charged objects interact. Rather, the principle of least action constrains all interactions between all things. It is all pervasive at all times. Further, it is not operating at the local level of individual objects alone. The principle of least action is seen in semi-isolated systems and ultimately will hold most perfectly of the entire world. Given that the universe is totally physically isolated, it is where global principles like the principle of least action are perfectly observed. The fact that the principle of least action operates at such high levels makes it problematic for Dispositional Essentialism. This is because, as we saw, Dispositional Essentialism aims to explain modality from the bottom-up via fundamental properties.

In what follows I will look at three ways that the principle of least action can be reconciled with Dispositional Essentialism. The first two are found in the literature; the third is my own proposal. These are:

(i) Explain the principle of least action as the result of non-global laws

(ii) invoke a high-level entity to bear high-level properties that ground the principle of least action
(iii) invoke collective properties which ground the principle of least action

These three strategies somewhat mirror the three strategies available for accounting for conservation laws. I will argue that there are various ways of accounting for the principle of least action. I start by showing that it is possible to account for the principle of least action via motion laws as per (i). However, in my view this strategy is not explanatorily satisfactory. After, I look at (ii) and (iii). (ii) regards the world-kind or universe-system hypothesis. I will keep the exposition brief as I have already explained the world-kind hypothesis; however, this will provide fruitful discussion on the nature of the principle of least action and global laws generally. (iii) is my strategy of using collective properties to account for global principles. I argue that both (ii) and (iii) are possible, but that we ought to favour my strategy – (iii) – as it is more parsimonious to no explanatory disadvantage.

5.2.1 The Principle of Least Action vs regular motion laws

There are various ways of explaining the trajectory of an object or the evolution of a system. Each physical theory – classical physics, general and special relativity, quantum physics, etc. – has its own laws for this. The principle of least action, in one form or another, exists in all these physical theories (Smart and Thébault, 2015; Terekhovich, 2018). My focus will be mainly on the classical physics case as an exposition of each variant is beyond the scope of this chapter. However, my conclusions take the pervasiveness of the principle of least action into account. In what follows I look at the first strategy the dispositional essentialist can use to explain the principle of least action i.e. to explain it via non-global laws.

In classical physics, the motion of an object must follow certain laws. For instance, Newton posited that objects will either persist in a state of rest or uniform action unless forces act upon them. According to Newton, F = ma, i.e. force is equal to mass times acceleration. Using his laws of motion, we can determine the trajectory of an object via its initial position, its velocity and the forces acting upon it or via its position at a couple instants and the forces acting upon it. Forces are important to this kind of explanation because they are responsible for all changes in the trajectory of an object. If I let go of an

apple, and there is nothing to prevent it falling, the gravitational force directs the apple to the ground (Terekhovich, 2018).

The principle of least action provides an alternative way to calculate the trajectory of the apple. In particular, the principle of least action allows us to calculate the trajectory of the apple using its initial and final positions. Whichever trajectory expends the least action is the one which occurred.

Not only are there various laws we can invoke to calculate the trajectory of an object, or the evolution of a system, these explanations are not independent of each other. As we saw, Newton's work allows us to calculate the trajectory of an object simply by its position at couple of instances and the forces that act upon it. However, this does not seem so different from the principle of least action. The principle of least action seems like a limiting case of this, whereby we have the initial and final positions specifically – rather than any positions whatsoever. However, the principle of least action is providing a unique insight into the workings of the universe and a new kind of explanation for motion.

The principle of least action brings new information to the table. Whereas Newton explains motion in terms of forces, the principle of least action explains motion in terms of kinetic and potential energy. The force of the principle of least action lies in its generality. It tells us that the trajectory of all objects and the evolution of all systems, everywhere at all times, minimize action. This sort of high-level regularity requires explanation from a dispositional essentialist perspective, given that one of the aims of this view is to account for all modality. Let's see how the first strategy fairs – explaining the principle of least action via motion laws.

According to Joel Katzav, we can deduce motion laws from the principle of least action. He points out that, by extension, we can derive the dispositions of things via the principle of least action. The principle of least action allows us to derive the motion laws; the motion laws allow us to deduce the dispositions objects have. This is Katzav's preferred direction of explanation. It goes from the top – the principle of least action – down to motion laws and finally dispositions. The principle of least action can account for motion laws. However, the reverse is also possible - motion laws can account for the principle of least action.

The principle of least action can be deduced from the laws of motion. "For example, the restricted version of the PLA [principle of least action] that is used in classical particle mechanics … can be derived from the Lagrange formulation of the equations of motion of such systems" (Katzav, 2004, p. 212). (For a discussion of how this can be done in other physical theories see Terekhovich (2018)). He also points out that explaining the principle of least action via these motion laws is consistent with Dispositional Essentialism. By extension, we can deduce the principle of least action from ordinary dispositions. The ordinary dispositions ground the motion laws from which we deduce the principle of least action. This is in keeping with Dispositional Essentialism's ordinary mode of explanation.

We can derive the principle of least action from motion laws and vice versa. However, the question arises of which explanation is better. Are the motion laws fundamental and the principle of least action derivative or vice versa? Katzav argues for the explanation that goes from the principle of least action down, to motion laws and then dispositions. In fact, he doesn't even consider the "explanation" from dispositions to motion laws to the principle of least action an "explanation". He says that we can deduce the principle of least action from motion laws, but he is careful to differentiate deduction and explanation. He does not see this move as explanatory.

The explanatory force of the principle of least action lies in its generality. It is a prime candidate for a global principle exactly because it explains high-level patterns of behaviour in terms of a simple, unifying law. Any system is compatible with a number of motion equations. The principle of least action is able to predict the actual motion equation in all these cases. In Katzav's words "The deductions that the PLA [principle of least action] affords seem to gain further explanatory strength from their unifying force. Such deductions appeal to a single scalar quantity in order to decide how the objects within a physical system will evolve, no matter how complex the system and its evolution." (2004, p. 212)

The principle of least action also appears explanatory because there is a version of it in all major scientific theories. "It applies, in one form or another, to all physical theories including general and special relativity, quantum mechanics, quantum field theory and even string theory." (Smart and Thébault, 2015, p. 388) We can deduce the principle of least action from the laws of each of these theories. However, each theory has different laws. As a result, the deduction of the principle of least action from the laws will be

different in each case (Terekhovich, 2018). The principle of least action survives, remaining through paradigm change, making it seem more fundamental and better established than the laws being used to explain it.

For Katzav, explaining the principle of least action via motion laws is the only way of saving Dispositional Essentialism. He presents us with a choice: either the principle of least action is explained bottom-up via motion laws or Dispositional Essentialism is false. This is because, on his view, Dispositional Essentialism requires all modality to be grounded by the dispositions of fundamental objects. Thus, for Dispositional Essentialism to work global principles like the principle of least action must be explained from the bottom-up.

Katzav grants that the principle of least action can be deduced from motion laws. He sees this move as weak for the reasons given. As he points out, scientific explanations tend to go from the top (the principle of least action) down. Smart and Thébault (2015, section 5) counter that the fact that scientists use that direction of explanation does not guarantee that that is the direction of the metaphysical explanation. In other words, we cannot know simply from this that the top-level does, in actual fact, explain the bottom level. Nonetheless, I agree with Katzav that bottom-up accounts of the principle of least action are not compelling. The principle of least action captures a high-level regularity, which requires explanation. Further, it seems more fundamental than the laws invoked to explain it. However, I leave this avenue open for dispositional essentialists. It is not a problem for my view if the tides turn and physics uncovers more warrant for a bottom-up account of the principle of least action. If anything, it is good for Dispositional Essentialism as it has one fewer global principle to worry about. My work leaves it up to science to determine which global principles are fundamental.

However, I disagree with Katzav's view that we must explain the principle of least action from the bottom up or do away with Dispositional Essentialism. In my view, rejecting a bottom-up explanation of the principle of least action is not cause to abandon Dispositional Essentialism. There is room in our metaphysics for both the principle of least action and Dispositional Essentialism. In what follows I will look at other ways of reconciling the principle of least action and Disposition Essentialism.

5.2.2 Back to world-kinds

Ellis contra Katvaz argued that dispositional essentialists need not account for the principle of least action from the bottom-up – via non-global laws. According to Ellis, the pressure for this sort of account is only a problem for naïve dispositionalism. Here naïve dispositionalism is the view that ordinary objects and their dispositions ground all laws. Ellis sees himself as a sophisticated dispositional essentialist where "A more sophisticated dispositionalist takes the view that how things are disposed to behave depends also on what kinds of things they are, what kinds of properties they have, and how these kinds of things and properties are placed in the natural kinds hierarchies to which they belong." (2005, p. 90)

Ellis' sophisticated Dispositional Essentialism consists of more than a basic level of objects and their dispositions. He is a realist about natural kinds, and he believes that natural kinds (and thus members of these kinds) have certain dispositions. As we saw, he believes that the world, as a member of the world-kind, has certain global properties that can give rise to global principles. For Ellis, if the world has dispositions there is little mystery to the principle of least action.

> "Lagrange's principle of least action applies to all physical systems, and I would suppose it to be of the essence of the global kind in the category of objects or substances. If this is so, then, of course, every continuing object must be Lagrangian, i.e. disposed to evolve in accordance with the principle of least action." (2005, p. 91)

On Ellis' view, the dispositions of the world don't just account for the principle of least action – they make it metaphysically necessary. For Ellis, global principles are not causal laws. They are not rooted in a causal power a property can trigger. They do not require "triggering" at all. After all, the universe is causally closed so, by definition, nothing can trigger them to manifest. Global laws are also not spontaneously triggered in the way an atom spontaneously decays. Rather, they are ever-manifesting. I will delve into this notion of non-causal laws soon but first I look at Katzav's objection to the necessity of the principle of least action.

According to Katzav, Ellis' proposal makes things worse. Interestingly, on Katzav's view, the necessity of minimizing action is at odds with the principle of least action. This

is because, the principle of least action requires that many different trajectories or motion equations are possible for every system. According to Katzav, the principle of least action presupposes that there are different trajectories an object can take or different quantities of action a system can expend. This makes sense of us saying that the trajectory which minimizes action occurred. After all, if there were no other possible trajectories that would be trivial. In Katzav's words: "The PLA (principle of least action), accordingly, presupposes its own contingency." (2005, p. 92)

Katzav's objection to Ellis presupposes that the principle of least action requires physical contingency. In other words, he assumes that the quantity of action could have been otherwise. However, Smart and Thébault (2015) show that this is not the case. They argue that Ellis' move is legitimate because the principle of least action is logically contingent, and this is the only kind of contingency that is necessary. They are building on a point Bird made (2007) in a different context.

Bird is sceptical of global principles. He sees the presumption of the physical contingency of the principle of least action as a misnomer. This is because he ultimately expects that the dispositions of regular objects will show that their action could have only been so as to minimize action. He sees the principle of least action as an *a posteriori* way of figuring out and explaining why systems evolved in a certain way when, in reality, they could have only evolved that way anyway. Again, I set aside Bird's scepticism of global principles as I have already argued against it in the previous chapter. The important point that Bird makes is that "It is natural to say that the PLA (principle of least action) chooses one path from many possible paths. But the mathematics of the PLA do nothing to show that such paths are metaphysically possible. The sense of 'possible' is a mathematical/logical one." (2007, p. 214)

Smart and Thébault second Bird's point about contingency (2015, section 4). However, they use it to argue that the principle of least action can indeed be accommodated in the way Ellis proposes. Many trajectories are logically possible. We can imagine that the trajectory of an object could have been different, expending double the action. Those imaginings are consistent with the laws of logic. However, the fact that we can imagine a violation of the principle of least action does not mean that it could actually occur in practice. According to Smart and Thébault, there is no reason why we should demand physical contingency. In other worlds, there is no reason to assume that the trajectories which expend excess action could have actually occurred. I agree with Smart and

Thébault but I think we can put the point across more forcefully still. It seems odd to think that the principle of least action requires its own physical contingency. It is bizarre that a global law, which constrains all interactions, requires the possibility of its own violation.

Earlier we saw that global principles are often spoken about as constraints. They constrain how systems evolve. In the case of conservation laws, we saw that there were many possible interactions objects could have, conservation laws constrain which interactions can occur in practice. No action can occur which alters the total amount of mass-energy, momentum, angular momentum, leptons, etc. There is a strong parallel here with the principle of least action as another global principle. Prima facie, there are many different trajectories an object can take, or ways a system can evolve. The principle of least action tells us which one actually occurs. The trajectory which requires the least action occurs. The principle of least action constrains because it does not allow systems to expend unnecessary action.

Global principles – conservation laws and the principle of least action particularly – are contrasted with all other laws. Ellis differentiates causal laws from global laws. A causal law is a law grounded in an ordinary causal power of an ordinary object. It is subject to being triggered by external properties, and its manifestation is conditional on the conditions to manifest. However, the principle of least action is not like this. In Ellis' words "…the truthmaker for the principle of least action is not what we should ordinarily think of as a causal power, because the property of Lagrangianism is a truly universal property – one that is possessed by every object in the universe." (2005, p. 91) Moreover, the principle of least action cannot be triggered. It applies to everything at the global level, so nothing external can trigger it to manifest.

For Ellis, the principle of least action is a global law. It is a global law because it applies to everything in existence. It cannot be triggered but it is always manifest. Hence, it resists bottom-up explanation and constrains all interactions within the world. Ellis is not the only one to differentiate high-level laws from causal laws. This sort of distinction is familiar in the literature on non-causal explanation. Lange contrasts causal laws with laws that constrain. Global principles, as I have called them, are of the latter type. In his words: "an explanation by constraint works precisely by providing information about the way that the explanandum arises from laws spanning diverse kinds of causal

interactions. As "constraints", those laws do not depend on the particular kinds of interactions there actually happen to be." (2018, p. 18)

The idea of a continually manifesting disposition may seem at odds with the way I have portrayed Dispositional Essentialism. I gave the most common reading of properties as dispositions to certain manifestations (M) given certain stimuli (S). However, some are critical of this kind of a reading (Vetter, 2012, 2015; Heil, 2017). They prefer to see properties simply as dispositions to manifest. On their view, properties may not always manifest because they compete with so many other dispositions, which may win out. This provides a useful framework for understanding dispositions of the world and global principles.

If the world has dispositions, those dispositions are ever-manifest. There can be no external stimulus for global dispositions or dispositions of the world. The world is causally closed and incorporates everything in existence. Thus, there are no competing, triggering or inhibiting dispositions. Nothing can be external to the global whole, acting on it. If the world has ever-manifesting dispositions, Ellis is right: there is no mystery to why the global principles they ground are exceptionless. Global principles are the manifestations of those dispositions.

Before concluding this section, it is worth noting that this debate could easily be rephrased in terms of Chakravartty's systems mentioned in the previous chapter. We could replace world-kind with universe-system. However, the objections and responses raised would still apply. The key issue here is whether postulating a high-level entity to explain the principle of least action works. I have shown that this is a live option for dispositional essentialists. However, this strategy can be improved via the collective property machinery I introduced earlier.

5.2.3 My account of global principles within Dispositional Essentialism

In this section I forward my proposal, explaining how we can do away with high-level entities when accounting for the principle of least action. Again, I keep my exposition brief as I argued for this approach in the previous chapter and showed how it can be applied in the section on conservation.

In the literature it is assumed that, if there is a global property which grounds the principle of least action there must be a global entity bearing that property. This

presupposes that property instantiation is a one-to-one relationship whereby every token property is instantiated by a single object. However, in the previous chapter I argued against this assumption. I argued for the possibility of collective property instantiation. Briefly, collective properties are properties that are instantiated by multiple objects, as opposed to instantiated by a single object.

Global entities are not necessary for global properties and global laws. The collection of fundamental objects that makes up the universe can collectively bear any property the world-kind or universe-system was postulated to bear. The universe is nothing over and above the sum of fundamental entities, their properties and the high-level properties they collectively bear.

Ellis argued that the world-kind or universe-system instantiates a non-causal Lagrangian disposition, and that this disposition gave rise to the non-causal principle of least action. My proposal is simply that the collection of fundamental objects in the universe jointly instantiate the Lagrangian disposition instead. This explains why all objects, down to the most fundamental, obey the principle of least action.

In sum, my view is that the world or universe is the collection of its constituent entities, rather than an entity in its own right. The collection of fundamental objects in the universe can collectively instantiate any property that the global entity was postulated to bear. Further, I argued that we ought to favour this reading because it is more parsimonious. Rather than postulating a world-kind, with the world as its member, and the Lagrangian property; I simply postulate the latter – the Lagrangian disposition to minimize action.

Conclusion:

I have shown that there are various avenues available for the dispositional essentialist to account for the principle of least action. The first – (i) - is to try to explain this principle away as the result of non-global laws. (ii) is the dominant one in the dispositional essentialist literature. (ii) invokes a high-level entity whose properties ground the principle of least action. Finally, I forwarded my proposal - (iii). This is an improved strategy relative to the world-kind one. Rather than postulating a high-level entity, I have argued that the collectivity of entities in our current ontology can do the job of bearing the property needed to account for the principle of least action.

My goal has been to show that there are quite a few ways out of the global principle conundrum for dispositional essentialists. The principle of least action is not as damning for the view as it first seems. It is not a problem for my view if the principle of least action is explained from the bottom-up per (i). If anything, it is a victory for Dispositional Essentialism to have one fewer global principle to account for. However, I find this solution unlikely. As a result, I forwarded a way of coping with the principle of least action taken as a serious global principle. I take my collective property approach to be an improvement on the existing world-kind approach. It is more parsimonious to no explanatory disadvantage.

6. Ontic Structural Realism as an alternative to Dispositional Essentialism

Ontic Structural Realism is a highly controversial but increasingly debated view in the philosophy of science. Its controversy lies in its metaphysics. Broadly, Ontic Structural Realism is the view that only structure exists. However, it is not always clear what that means. Structure could be taken to mean abstract structure – higher-order relations among properties – or mathematical structure, say, lawlike equations. This explains why Ontic Structural Realism raises so many eyebrows, accused of being unable to account for causation and having relations but no relata. However, increasingly ontic structural realists talk about modal or concrete structure (Esfeld and Lam, 2011; French, 2014). In this chapter, I look at the history of Structural Realism and how Ontic Structural Realism came to be. I will show that Ontic Structural Realism and Dispositional Essentialism both aim to ground modality and I will consider the arguments for Ontic Structural Realism's approach to this. In doing this, we will see the often unappreciated proximity between these two views.

This chapter is divided into three parts. In the first part, I introduce Epistemic Structural Realism. This is the view that all we *know* is structure (rather than the view that all there is is structure). Epistemic Structural Realism provided the historical and philosophical context for the development of Ontic Structural Realism. We will see how the arguments for the view that we only know the structure of reality (the epistemic view) paved the way for some philosophers to argue that all there is is structure (the ontic view).

In the second part of this chapter I will lay out the scientific arguments given for Ontic Structural Realism. These are probably the biggest factors in the increasing popularity and debate of this view. We had already seen that physics breaks with traditional ontology by allowing objects to have entangled properties. In section 6.2 we will see that physics causes problems for individuating objects. Further, we will see why ontic structural realists argue that their view best accommodates the science.

The third and final section is the longest. It covers the metaphysical arguments for Ontic Structural Realism, varieties of Ontic Structural Realism, the ontology of prominent ontic structural realists, and the proximity of this view to Dispositional Essentialism. I will be particularly focused on philosophers who compare Ontic

Structural Realism to Dispositional Essentialism (Esfeld, 2009; Esfeld and Lam, 2011; French, 2014; Chakravartty, 2019). I am interested in this as the proximity of these views is vital to my thesis which, ultimately, aims to forge a hybrid view between the two. There is additional benefit in focusing on authors who compare Dispositional Essentialism and Ontic Structural Realism as these authors tend to be the most explicit and engaged with the metaphysics of Ontic Structural Realism. As a result, they give the clearest picture of the underlying ontology of the view. We shall end by seeing that Steven French – perhaps the best known ontic structural realist – claims that this view is a reverse-engineering of Dispositional Essentialism. Whereas Dispositional Essentialism takes properties to be fundamental and laws derivative, Ontic Structural Realism takes laws and symmetries to be fundamental and properties to be derivative. This sets the scene for my next chapter where I argue contra both views that there is no metaphysical priority between properties and laws. Properties and laws are symmetrically dependent on each other.

6.1 Epistemic Structural Realism

In this section I will give a brief overview of how Ontic Structural Realism's predecessor – Epistemic Structural Realism – came into our philosophical consciousness and gained traction. I will focus on the most common arguments given for this view. In particular, I will explain why structural realists believed it to be the only view able to accommodate the complex history of science and the resultant challenges to both realism and anti-realism in science. Then, in the following sections, we will look at how Epistemic Structural Realism allowed for the creation of another competing view: Ontic Structural Realism. These two views differ on whether they take Structural Realism to be best understood as an epistemic thesis about what we can know or an ontological thesis about what actually exists.

Epistemic Structural Realism was forwarded as a solution to the two most famous and contradictory arguments in philosophy of science. The first is known as the no miracles argument. It fuels scientific realism – the view that our best scientific theories are getting at truth. The second is pessimistic meta-induction. This fuels anti-realism about scientific theories, especially regarding unobservables. It aims to show that we have

little or no reason to assume that our current scientific theories about the unobservable are any closer to the truth than their predecessors were.

According to the no-miracles argument, it would be a miracle if our best scientific theories were not true (Putnam, 1975; Worrall, 1989). Our best scientific theories have a wide range of application. They are not just able to explain why our world works the way it works, they are able to predict the future. They tell us what will happen before it happens. If these theories are not at all true, their success would be an accident. Given how often they are right, this would seem rather miraculous. Yet, miracles provide poor scientific explanations. Ergo, scientific realism is true.

On the other hand, we have the pessimistic meta-induction argument, pulling us towards anti-realism (Laudan, 1984). The pessimistic meta-induction argument points to the fact that predictively successful theories are constantly being overturned. They get replaced by even more successful theories which in turn end up being replaced by even more successful theories, and so on. Take the example of Newtonian physics. Newtonian physics was highly predictively successful.

> "Newton's theory of gravitation had a stunning range of predictive success: the perturbations of the planetary orbits away from strict Keplerian ellipses, the variation of gravity over the earth's surface, the return of Halley's comet, precession of the equinoxes, and so on. Newtonians even turned empirical difficulties (like the initially anomalous motion of Uranus) into major successes (in this case the prediction of a hitherto unknown trans-Uranian planet subsequently christened Neptune). Physicists were wont to bemoan their fate at having been born after Newton – there was only one truth to be discovered about the 'system of the world' and Newton had discovered it." (Worrall, 1989, p. 103)

Despite its predictive success, Newtonian physics has been superseded by Einstein's relativistic physics.

Newtonian physics clearly has a wide range of applicability and predictive success. However, as we reach large macro-scales it breaks down. At this scale, Einstein's relativity theory is required for accurate prediction. However, this theory has involved a reconceptualisation of space and time that Newton could scarcely have imagined. Newton thought that space and time were absolute and infinite. As such, the present is

exactly the same from all point of views. Nothing can be simultaneous for two agents but not for a third. Einstein paints a very different picture of spacetime. Spacetime is finite and non-absolute. The gravitational forces of objects can warp the spacetime around them. This allows objects that travel fast enough to slow down time from their perspective so that they decay at a slower rate than the objects around them (Dainton, 2010; Stanford, 2006).

Despite the success of Einstein's relativity over Newtonian mechanics "Newtonian mechanics is still the physics we use to send rockets to the moon" (Stanford, 2006, p. 9). This is because it works at that range and is much simpler than the more advanced theory. However, that does not make the Newtonian mechanics "true". Newtonian and relativistic space and time are completely different. Space and time cannot both be finite and infinite, absolute and relative. If Einstein's theory is true, some aspects of Newton's views on the nature of spacetime are false. We might be tempted to think that Einstein got it right, but we have good reason to resist this conclusion.

General Relativity is great at explaining and predicting the workings of the universe on a large scale. On the other end of the spectrum we have Quantum Mechanics – our best science of the smallest entities in the universe. The issue is that these two views do not mesh well. An explanation of why is beyond the scope of this thesis. Suffice to say that scientists are still working on how to reconcile General Relativity with Quantum Mechanics. These two seem inconsistent despite their predictive success in their own domains. The pessimistic meta-induction advocate would use this to not only undermine our confidence in these theories, but also our confidence in any future theories which supersede them. They would point out that time and time again theories are overturned so the next theory will probably be overturned too. However, this level of pessimism may not be warranted.

While Newtonian physics was overturned by Einstein's relativity, Newtonian physics can still be regarded as a limiting case of Einstein's relativity. By this I mean that, for a certain scale (which covers most uses) Newtonian physics and Einstein's relativity both work. Further, as mentioned above, Newtonian physics is often our theory of choice at that scale because it is much simpler. This overlap is perhaps not surprising given the level of predictive success of Newtonian physics. It would, indeed, be miraculous if Newton had gotten everything wrong.

In *Understanding Inconsistent Science*, Peter Vickers surveys the history of science to show many examples of theories which are not even internally consistent. However, he shows that inconsistency is not always equally damning when the goal is proximity to truth. If two criminals get confused about a previously agreed alibi that is indeed very damning (2013, p. 1). However, other inconsistencies may be minor. If three of us go to lunch and I say "your third costs £27" but then pressed by the other person I say "fine, it was £27.05" these two do not seem inconsistent in a meaningful way. Certainly, many of the inconsistencies that lead to theory change are meaningful but that does not render the past views entirely false. As Vickers put it "A set of inconsistent assumptions can be approximately true in the strongest possible sense: when every assumption is true except for one, which itself is approximately true." (2013, pp. 73-4) We do not yet know how Quantum Mechanics and Relativity will be reconciled. Detailed speculation is beyond the scope of this work. However, it seems likely that the view that supersedes them will retain some of what made them individually successful. Perhaps we will even be able to look back and see them as limiting or special cases of the bigger picture to come.

This tension between the no-miracles argument and the Pessimistic meta-induction brings us to Epistemic Structural Realism (henceforth Structural Realism), popularised by John Worrall (1989). Worrall proposed Structural Realism as a systemic solution to the no-miracles-pessimistic-meta-induction gridlock. Worrall accepted that there is a cumulative aspect to scientific theories, whereby new theories improve on the older ones. However, he argued that there was also a non-cumulative aspect of theory change. In his view, we could single out this non-cumulative aspect. In particular, he pointed out that, as theories change, the underlying ontological assumptions about the world are generally not retained. In fact, they shift radically.

Structural Realism accepts radical shifts at the theoretical level of science, however it also addresses the cumulative aspect of science. The idea that current theories improve on their predecessors allows for progress in science. According to Structural Realism, there is progress at the structural level (more on what structure can mean below). The equations of old predictively successful theories often work as limiting cases of the newer theories. This point is illustrated by the examples of Fresnel and Maxwell's theories of light as well as Newton and Einstein's physics.

Frensel believed that light was the manifestation of disturbances originating in a source and transmitted in an all-pervading mechanical medium – ether. His equations outlined the motion of light and enjoyed predictive success. The most famous prediction being the "prediction of the white spot at the centre of the shadow of an opaque disc held in light diverging from a single slit." (Worrall, 1989, p. 116). Yet, Maxwell's electromagnetic theory superseded Frensel's. Seeing light as wave-like changes in an electrical and magnetic field enjoyed a wider range of explanatory and predictive success. While it is true that Maxwell hoped to be able to give an account of the electromagnetic field in terms of some underlying mechanical medium – like ether - his attempts and those of future scientists failed to do so. This led to the eventual rejection of an underlying medium and acceptance of the electromagnetic field as primitive (ibid, p. 108) Light can be a disturbance in an electromagnetic field. However, light can also travel through empty space not requiring a medium or electromagnetic field at all. That said, there is a sense in which there is progress from Frensel's to Maxwell's theory. Frensel's equations act as limiting cases of Maxwell's equations. In other words, Frensel's equations still work – they would still allow us to make correct predictions – for certain values. However, Maxwell's equations have a much wider range of success.

Earlier we saw that Newton and Einstein had extremely different views of the nature of space and time (or spacetime). These are logically inconsistent with each other: the truth of one entails the falsity of the other. If spacetime is relativistic it is not absolute. If it is finite it is not infinite. However, there is a sense of continuity between these views. Einstein's theory superseded Newton's, enjoying a wider range of predictive success. However, Newton's theory is still observationally indistinguishable and predictively successful at a certain scale. At the scale of everyday events, and movements of nearby planets we can use Newtonian laws. It is only when we look at the macroscale that we need relativity theory and witness spacetime warping. Newton's equations are limiting cases of Einstein's (Worrall, 1989, p. 103)

Structural Realism acknowledges both the continuity and discontinuity of science. It says that, at the structural level, science is cumulative. As theories change our knowledge of the structure of reality is increased and refined. Previous knowledge is not lost but is added to. Structural Realism nods to the no-miracles argument. It agrees that it would be miraculous if our best science is mostly wrong. However, it takes the root of the success of our best science to lie in it mapping the structure of reality correctly. And, it expects that structure to mostly be retained through theory change.

One issue that pops up in discussions of Structural Realism is what is meant by structure. What does it mean to say we know the "structure" of reality? I will talk about this in more detail in the discussion of Ontic Structural Realism where this takes on a new level of urgency and difficulty. However, in the present case, the structure of reality is mathematical and relational. On one hand, the structure can seem entirely mathematical – a collection of equations. However, those equations are laws of nature, expressing relations between the properties of unobservable entities. The mathematical equations in Newton's theory were supposed to encapsulate the relations between force, mass, acceleration, etc. Our structural knowledge of these things is improved upon by Einstein. General Relativity introduces new data about the structure of the world on a macro-scale. Some of this data contradicts Newton's predictions, but Newton's equations still function as limiting conditions of Einstein's. This understanding of structure can be traced back to Poincaré (1905) who says that these equations express relations, and if the equations remain true, it is because the relations preserve their reality." (p. 162 cited in Worrall, 1989, p. 118)

This section purposed to briefly lay out Epistemic Structural Realism as historical context for understanding Ontic Structural Realism. It is far from comprehensive and does not aim to defend the view. Nonetheless, there are some important criticisms which deserve a brief discussion. In particular, I will look at Newman's objection, the issue of counterexamples and scepticism over the structure/nature dichotomy. An understanding of the strength of this view will help motivate the view I look at in the next section – Ontic Structural Realism. This is a new, much more radical Structural Realism which takes structure to be all that exists. Ultimately, I want to bring similarities between this view and Dispositional Essentialism to light. This will motivate my own view, which is a hybrid between the two, but for now I will wrap up the topic of Epistemic Structural Realism.

The first objection to Structural Realism I look at was forwarded by Max Newman in 1928. It was levelled at Bertrand Russell's 'causal theory of perception'. Russell stated that we could only really know the structure of reality, paving the way for Structural Realism as we know it today. Newman objected that this trivialises knowledge, leaving us with no real knowledge of the world. In his view knowing the structure of reality does not amount to knowing much about reality at all:

> "Any collection of things can be organised so as to have the structure W, provided there are the right number of them. Hence the doctrine that *only* structure is known involves the doctrine that *nothing* can be known that is not logically deducible from the mere fact of existence, except (" theoretically ") the number of constituting objects." (Ibid, p. 144)

Structural Realism fails to fix reference to the things that instantiate structure. The structure of the world can be instantiated by literally anything – electrons or cakes. According to Newman, at best Structural Realism tells us how many things instantiate the structure. Even this is arguable as there could be two things instantiating a part of the structure and we would be none the wiser. Thus, all we know about reality is the minimum number of things that make it up.

There are various possible responses to Newman's objection. First, recall that his was an objection to a specific kind of structural realism with a specific understanding of structure. He took issue with the view that no matter how hard we try, or how much science we do, we cannot know anything non-structural. Here by structure he means the abstract mathematical structure of the world. Thus, we cannot know anything intrinsic about what instantiates the structure. For Newman we barely have enough to refer to the objects instantiating the structure. All we have are abstract theorems which could be instantiated by anything.

> "Now if an aggregate A consists of objects of which nothing is known but their existence (supposing such a statement to have a meaning) it cannot, I think, be shown that there is a system of "real" relations with the field A and structure W. Even the assigning of names in such an aggregate is difficult to justify. We cannot say "Let this be *a* and that *b*," for there is no possible way of explaining the reference of "this" and "that"" (Newman, 1928, p. 145).

One way of dealing with this is to bite the bullet. The structural realist may well think that all that can be known about reality is its abstract structure. For the purpose of this thesis, I will not be interested in this kind of response.

Another kind of response is to reject the idea that all we know about reality is its *abstract* structure. As I hinted at earlier, the notion of structure has many interpretations. It can mean abstract structure, concrete structure, it can be

mathematical or modal. Let's look at one of the "abstract theorems" F = ma – force equals mass times acceleration. Sure, the abstract structure can be instantiated by anything which is equal to the product of two things. However, the question is whether that is all the information the structural realists takes this equation to give us.

While Structural Realism is not primarily a view about properties, I am interested in what Structural Realism (particularly Ontic Structural Realism) tells us about these. In the example of F = ma, to think that we know nothing about F is reminiscent of the Categoricalist view of properties (French, 2014, p. 118). However, I am obviously biased towards dispositionalist views of properties which I argued for at length early in this thesis. Within a dispositional essentialist framework we do know the essential nature of F – force - when we know what it does. And nothing can take F's place in the structure of the world. This is because F's role is uniquely written into its essence. What properties do and what they are are two sides of the same coin. Similarly, if we take the structure of the world to be the result of the properties of underlying objects, seeing those properties as dispositions helps us latch onto those objects.

Along the lines of the previous response, structural realists can claim that by knowing the structure of the world we do know something beyond mathematical formalisms. This response hangs on what the structural realist takes structure to mean. As we saw, Russell took structure to be abstract structure. Abstract structure here means higher-order, formal properties of relations (Chakravartty, 2007, p. 40). In contrast concrete structures "are relations between first-order properties of things" (Ibid, p. 41). The same abstract structure can be instantiated by different concrete structures (ibid, p. 40). The concrete structure cannot be multiply realised. At least not if we see properties as at all modal or dispositional. To know the relations between first-order properties is to know those properties, at least within the dispositional property framework argued for in this thesis.[13] Thus, one way out of the Newman objection is to take it that we have knowledge of the concrete structure of the world.

[13] While I brought up dispositionalism about properties as a parallel here, the parallel isn't perfect. It is possible to have this sort of view about properties but not objects. We can pair the idea that properties are known via there structure or dispositions with a multitude of views of objects. A dispositionalist could believe that the same group of properties can be multiply realised by different objects, or we can have a structuralist view of objects where all there is to being a certain kind of object is having certain properties. Later in the chapter we will look at Esfeld's view as an example of the latter. He endorses a dispositional view of properties and a structural

In addition, as we shall see later, Ontic Structural Realism provides another escape from Newman's dilemma. This is because Ontic Structural Realism holds that reality is structural. Thus, by knowing the complete structure of the world we know all there is to know about it. Like with Epistemic Structural Realism, this view takes on different tones according to how we understand structure.

Stathis Psillos has argued against the nature and structure dichotomy of Structural Realism. On his view, this distinction is artificial because the structure and nature of entities are entwined. Contra structural realists he points out that "when scientists talk about the nature of an entity, what is normally understood is a bunch of basic properties and a set of equations, expressing laws, which describe the behaviour of this entity." (1995, p. 31). Further, in his view science and philosophy are moving away from positing unknown entities outside of the empirical realm. Thus, he concludes that the "nature of an entity is nothing 'over and above' its structure and that knowing the one involves and entails knowing the other." (p. 32)

The structural realist can respond to Psillos by softening the nature/structure divide without losing it altogether. In other words, they can show that our structural knowledge tells us something about the thing realising it. On the one hand, we can concede that Psillos has a point in the sense that knowing the structure of a thing may tell us about the nature of the thing itself. Back to our previous example, for philosophers of a dispositionalist inclination if F = ma (if force equals mass times acceleration) the relation to mass and acceleration is written into the nature of force. The behaviour of force is a manifestation of its nature. However, this is not to cave in to Psillos' view that the structure/nature divide is made up. The idea that the structure of the world is a manifestation of its nature is consistent with the view that we do not, and even cannot, have a full understanding of the nature of unobservable entities.

We know of unobservable entities because of their properties and the effects those properties have on the world. However, our methodology for studying the microphysical is limited "We are restricted, as it were, to poking and prodding at them with bombardments, and 'seeing' (through instruments) how they react. This informs us about the reactions, responses, and outputs that the fundamental entities produce in

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view of objects. He believes that properties and objects are only separable in thought so by knowing the properties a thing has we know the thing itself (Esfeld 2004, 2009; Esfeld and Lam, 2011).

response to testing…" (Williams, 2011, p. 77) This methodology allows us to build a dispositional or structural profile of the world. Some facts about unobservables elude us. If they are structural or dispositional facts we may come to refine them through theory change. If there are non-structural facts, these will be beyond the grasp of science and the empirical realm (Ibid). For now, we work with the dispositional and structural profiles we are able to study scientifically and fill in the blanks regarding the ultimate nature of the unobservable. The blanks we will fill in are often deemed wrong as theories change. The structural realist is right to think that our epistemic limitations are responsible for dramatic shifts in our understanding of unobservables.

The subject of the rest of this chapter – Ontic Structural Realism – responds to this kind of objection by saying that all there is is structure. Ontic Structural Realism rejects hidden natures by saying that structure is all there is. As a result, by knowing the structure of reality we know all there is to know about it. While this looks consistent with Psillos' view, Psillos is actually quite critical of it. This is because he fears that structure cannot account for modality or causation so that we do indeed need more than structure to tell the full story (2006, 2012). Nonetheless, we will see that Ontic Structural Realism has strong scientific and metaphysical motivations. Further, it comes in many flavours or degrees, some of which are more concerned with making sense of causation and bringing modality into the structure. I will cover some versions of Ontic Structural Realism and show how close its moderate versions come to Dispositional Essentialism. This will ultimately serve my goal of drawing up a new kind of dispositionalist view, fortified by the insights of Ontic Structural Realism.

The third and final objection I will consider here is quite different from the other two. Rather than poking holes at the conceptual framework of Structural Realism, it uses case studies to undermine the claim that structure is retained through entity change. This idea is key to Structural Realism. The idea that structure is preserved through theory change is what allows structural realists to respond to the pessimistic meta-induction and it is what makes the theory a form of scientific realism to start with.

The third objection proceeds by counterexample. Juha Saatsi and Peter Vickers (2011) point out that Kirchhoff's theory of light was predictively successful, yet its success cannot be accounted for by Scientific Realism. Scientific realists argue that predictively successful theories owe their success to the fact that they are getting at truth. Kirchhoff formulated an equation in optics which described the behaviour of light with

"remarkable accuracy" (Ibid, p. 30). Yet that accuracy is not owed to the theory's truth. At the theoretical level, Kirchhoff worked in the old ether paradigm. At the structural level, he seems to have got a lot wrong.

> "The predictive accuracy achieved is prima facie amazing for two reasons: it turns out that Kirchhoff's derivation turns on crucial assumptions regarding the amplitude of light waves that: (i) differ considerably from the actual situation (as described by Maxwell's equations, for example) in various respects, and (ii) as a matter of fact are inconsistent." (Ibid)

While this example is particularly striking, Vickers points out that there are quite a few cases where successful theories rely on faulty assumptions some of which will be structural (2016). Further, as we dig up examples in the history of science more examples may continue to pop up.

There are various responses the structural realist can give to counterexamples. One response is to try to narrow down which parts of the theory are doing the work. "Worrall makes the distinction in terms of the 'content' of a theoretical claim, which is idle, and the 'structure' of a theoretical claim, which is working and thus merits our doxastic commitment." (Vickers, 2016). However, this is difficult to do. It is hard to single out an aspect of structure which "works", and which will evade every counterexample. It is even harder to do this in a way that does not seem *ad hoc* (Ibid).

A second kind of response realists can give is that the success-to-truth inferences they make are generally reliable however they are not fool proof. The Kirchhoff case is one of the rare ones in which the success of a theory is a fluke rather than the result of its truth. Along those lines, the structural realist can argue that counterexamples are less of a challenge to Structural Realism than the original pessimistic meta-induction challenge to realism. Pessimistic meta-induction tells us that all our previous theories have been falsified so we have reason to think all our current theories will be too. The evidence at worst shows that sometimes structure is retained and sometimes it isn't. If on the whole the core structural findings of a theory tend to be retained, we will have better evidence for inferring their truth than their falsity. I'm sure structural realists would point out that there are not that many counterexamples where a successful structure is completely overturned.

Another way of looking at the problem is to accept that structure can change and that that is not necessarily a problem for Structural Realism. After all, structural realists are the first to say that structure changes in theory change. The structure of the prior theory generally becomes a limiting case of the structure of the successor theory. Sometimes the previous theories rely on faulty assumptions and are overturned as we get to a better understanding of reality. The problem only arises if the structural realist believes that successful structure is immune to error. However, Structural Realism as a view thrives on some amount of error and the idea that that error gets weeded out through theory change. This is based in the view that structure tracks real patterns in the world, the better our understanding of the world the more detailed our map of those patterns becomes. We simply can't assume that any particular part of structure is immune to error and will survive theory change as we do not know what new light the successor theory will cast on that structure.

6.2 Epistemic Structural Realism vs Ontic Structural Realism

Structural Realism was initially an epistemic thesis. In other words, it was a thesis about what we know about the world. It was the view that we can only know the structure of the world. Structural Realism has since been reimagined as an ontological thesis – a thesis about what the world is like, independent of our knowledge of it. Ontic Structural Realism has been summed up by the controversial slogan "There are no things. Structure is all there is." (Ladyman and Ross, 2007, p. 130) Broadly, it is the view that reality is structural. There is not a hidden reality over and above the structure captured by a final and complete science. However, as we have seen, what exactly is meant by structure is a controversial matter. Later in this chapter, as we discuss different versions of Ontic Structural Realism, we will see that there is not a one-size-fits-all answer. To begin with ontic structural realists were mostly eliminative and saw structure as mathematical, others argue that the structure is modal (French, 2014) or causal, drawing inspiration from causal views of properties like Dispositional Essentialism (Esfeld, 2004). However, I leave this for later. In this section my concern is with the arguments that spawned the view.

Ontic Structural Realism can be argued for in two different ways. The most common way is to argue that this view fits best with the discoveries of physics. Quantum

mechanics has led to much revisionary work in metaphysics. It has discredited traditional metaphysics and classical physics which took objects to be discrete and discernible individuals which individually bear properties. In this section, we will see how Ontic Structural Realists have used this work to argue for their view. The other kind of argument, which I leave for the next section, looks at the metaphysical case for Ontic Structural Realism.

6.2.1 Scientific motivations for Ontic Structural Realism

In this section I will show how the case for Ontic Structural Realism has been built on the issues Quantum Mechanics raises for our ability to individuate objects, particularly sub-atomic particles. In traditional metaphysics objects are individuated by their properties. According to the principle of identity of indiscernibles, if two things have all the same properties they are the same thing. Thus, we can differentiate objects by their properties. For instance, this chair cannot be the same as that chair because this one is red and here, that chair is blue and there. If two chairs share all the same properties, and are in the exact same location, they are not two chairs. They are one and the same chair. In this section I will show why ontic structural realists argue that this sort of discernment does not work at the subatomic level. Further, I will show why they argue that the individuality of particles in underdetermined by the evidence and that Ontic Structural Realism is the solution.

We have already looked at one way in which quantum mechanics defies traditional metaphysics. Quantum entanglement poses serious problems for the idea that reality is build out of fundamental objects and their respective fundamental properties, or that we can discern entities by their properties. Our best science tells us that quantum objects collectively share properties. I will not give a detailed explanation of entanglement as I covered this issue at length in chapter 4. That said, it is worth explaining how entanglement can motivate Ontic Structural Realism.

Michael Esfeld sees entangled properties as relational properties. Recall that if quantum objects are entangled they have joint properties which cannot be attributed to individual objects. Entanglement cannot be explained from the bottom-up. Entangled properties do not supervene on basic properties. They are basic properties. They are basic properties that are split between, or collectively instantiated by, multiple entities.

According to Esfeld "'Being entangled with" is a property that is predicated of at least two quantum systems; it is thus a relational property." (2004, p. 604).

In addition to entanglement being a relational property, it is extremely widespread in nature (ibid). It is so widespread that entanglement has led philosophers and physicists to see argue that quantum objects are nonseparable and the world is holistic (Esfeld, 2004; Healey, 1991; Teller, 1986; Schaffer, 2010). The second follows from the first. If we cannot separate the objects which constitute our world, their basic properties being relational and collectively borne, the world looks like an interwoven whole rather than a collection of independent particles and their properties. For some, the relational and holistic nature of the world points to Ontic Structural Realism (Esfeld, 2004). Ontic Structural Realism sits comfortably with reality as a relational web. However, entanglement is not doing all the work here. The most famous argument for Ontic Structural Realism draws from other aspects of physics.

The best known argument for Ontic Structural Realism stems from the underdetermination of the identity and individuality of particles. Again, the idea is to show that Ontic Structural Realism best accommodates the physics.

Sub-atomic particles do not behave as we would expect given our experience of the macro-world. Particles of a kind, like electrons, are not distinguishable. Particles are categorised "according to their possession of different values of a certain small subset of their properties, such as rest-mass, charge, spin, etc." (French, 1989, p. 435). So, we cannot differentiate particles on the basis on their intrinsic properties (properties which they have independently of other objects). In addition, we cannot differentiate particles by spatio-temporal properties since they do not have well-defined spatio-temporal trajectories and may not be impenetrable (so two particles could occupy the same position at once) (French, 1989, p. 443).

The following figure illustrates the ways in which two particles can be distributed between two boxes:

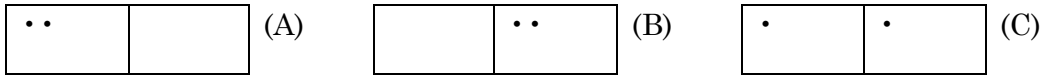


Figure 2

In classical physics arrangement (A) and (B) represent one state of affairs where (C) represents 2. In arrangement (A) particle 1 and 2 are in the left-hand box. In

arrangement (B) particles 1 and 2 are in the right-hand box. In classical physics (C) could represent two cases: either particle 1 is in the left box and particle 2 is in the right box or vice versa. If the distribution of electrons in the boxes is random, there is a 25% chance situation (A) will obtain, a 25% chance (B) will obtain and a 50% chance (C) will obtain (French, 1989, p. 435). However, this is not the case within quantum mechanics.

In Quantum Physics situation (A), (B) and (C) are given an equal weight of 1 so there is an equal 33,(3)% chance of any one of these situations obtaining. (C) is taken to represent one scenario, as opposed to two scenarios, because the two situations are indistinguishable. This is known as the indistinguishability postulate. According to this "there is no way of distinguishing states which differ by a permutation of the particles only. In other words, particle permutations are not regarded as observable in quantum statistics and do not give rise to countably distinct complexions." (French, 1989, pp. 440-1) This conclusion is widely accepted because of its empirical success; "to get the right statistics in quantum mechanics, whether for bosons or for fermions, we must count [permuted] arrangements… as one and the same." (Redhead and Teller, 1992, p. 204)

While many take the indistinguishability of particles to mean that they are not individuals, this is not the only metaphysical picture available. As Ladyman and Ross point out, failing to individuate quantum objects via their qualitative or spatiotemporal states, they may be given a transcendent individuality (2007, p. 134). We can still quantify how many particles are in a system even if we cannot individuate them. Thus, philosophers can argue that they are individuals in some other primitive sense. We can count them, we just cannot distinguish them.

One way to argue for the individuality of particles is to point out that discernibility is an epistemic notion (about what we can know) and identity is a metaphysical one (about what there is). So, our inability to differentiate two particles does not prove that they are not distinct. Nature might allow for indistinguishable objects. Further, some work has been done on alternative interpretations of the mathematics which allows for indiscernible individuals (an explanation of this is beyond the scope of this thesis, for more information see Redhead and Teller, 1992). However, it is worth noting that interpretations of quantum objects as individuals will still have to answer to why quantum statistics hold. They have to accommodate the uncomfortable fact that a permutation of two objects is not considered a different state from a statistical perspective (Ladyman and Ross, 2007, p. 136).

One of the main – if not the main – arguments employed for Ontic Structural Realism is that the individuality of particles is underdetermined by the evidence (Ladyman and Ross, 2007, p. 135; French 1989, p. 445; 2014, chapter 2) and that Ontic Structural Realism avoids this problem. In other words, quantum mechanics cannot conclusively determine whether particles are individuals or not. Quantum mechanics shows that particles do not behave as classical objects, in intuitive ways. However, the question of how we ontologise the data is a metaphysical one.

Ontic Structural Realism markets itself as the way out of the underdetermination problem. It dissolves the dilemma. Within this view there is no question of whether particles have transcendent individuality or not. Rather, the structure of the particles is all there is to the particles. Thus, there is no need to prod at further, mysterious, ways of individuating them. According to Ladyman and Ross, that sort of reasoning relies on an outdated metaphysics which philosophers try to impose on the science (2007). These ontic structural realists claim instead to be taking their ontology from science (Ibid; French, 2014). Science gives them a structural picture of subatomic particles and that suffices.

In the next section, I will look at some metaphysical arguments for Ontic Structural Realism. We will see that many of these motives are shared by Dispositional Essentialism, making these views closer than they first seem. In the course of the metaphysical exposition we will look at different varieties of Ontic Structural Realism.

6.3 A shared agenda: the metaphysical motives for Ontic Structural Realism and their proximity to Dispositional Essentialism

Ontic Structural Realism and Dispositional Essentialism are seldom mentioned together. They move in different circles, so to speak. Dispositional Essentialism is usually discussed in the metaphysics literature. It does not aim to radically reform our ontology, but to inform our understanding of properties. Ontic Structural Realism, on the other hand, tends to be discussed in the philosophy of science literature. Even its moderate forms are revolutionary, throwing traditional metaphysics out the window. However, we shall see that these two views are actually a lot closer than they first seem.

I begin this section by laying out the differences between Dispositional Essentialism and Ontic Structural Realism and giving an overview of different kinds of Ontic Structural Realism. After, I will look at the work of prominent philosophers who contrast these two views (French, 2014; Esfeld, 2009; Esfeld and Lam, 2011). These philosophers are keener to tackle the metaphysics of Ontic Structural Realism. As a result, they are probably the best sources for understanding the ontology of Ontic Structural Realism. Their work will also serve to lay the foundation for the rest of this thesis where I forward my own novel view of properties, laws and the relationship between them. This will be a sort of hybrid view – a combination of Ontic Structural Realism and Dispositional Essentialism's ontologies.

6.3.1 Ontic Structural Realism vs Dispositional Essentialism

In what follows I will show that Ontic Structural Realism and Dispositional Essentialism are quite close views. They share a similar motivation, although their ways of tackling the same issues will differ (Chakravartty, 2019; French, 2014; Esfeld, 2009; Esfeld and Lam, 2010). My goal for the rest of this chapter is to showcase the proximity between these views, and the work comparing them, in order to lay the groundwork for the next chapter where I finally forward my own view – a novel view which is a hybrid between the two. Before I move onto the similarities between the views, I will recap Dispositional Essentialism and show how Ontic Structural Realism differs. I then look at different versions of Ontic Structural Realism.

Dispositional Essentialism is primarily a view about properties. Or better, it is a cluster of similar views about properties all of which share the core idea that at least some properties are inherently dispositional. This is often understood to mean that properties are dispositions to certain manifestations given certain stimuli (Bird, 2007). However, it can also mean that properties are dispositions to manifestations simpliciter (Vetter, 2015; Heil, 2017). Some feel that dispositions are properties of fundamental objects (Bird, 2007; Heil, 2012), others accept that natural kinds can have properties (Ellis, 2001) and I have argued in the last two chapters that objects can collectively bear properties. Dispositional essentialists usually believe that dispositions give rise to laws (I have taken this as the default position in my work), although some think dispositions do away with the need for laws (Mumford, 2004).

Dispositional Essentialism comes in various shades regarding how exactly we cash out properties. Dispositional Essentialism does not comment on objects or take revolutionary stances on the fundamental ontology of the world. Dispositionalists, by and large, take a traditional stance on the object-property ontology. They see objects as bearing properties. These properties are often taken to be universals, assuming a traditional universal and particular ontology (e.g. Bird, 2007; Mumford, 2004). The same cannot be said for Ontic Structural Realism.

Ontic Structural Realism is arguably primarily a view about objects. It is a view about everything in existence, namely that everything is structural. However, in all its forms it is radically revisionary about objects. If you like ordinary objects, this is not the view for you.

There are many varieties of Ontic Structural Realism. Like with many views in philosophy, there may be as many kinds of Ontic Structural Realism as there are ontic structural realists. This is made particularly confusing by the fact that ontic structural realists often restrict themselves to the scientific literature and are not keen to spell out the metaphysics of their view (e.g. Ladyman and Ross, 2007). Sometimes they are even hostile to metaphysics (ibid), but we cannot do away with the metaphysics as the view is nothing if not a metaphysical view. It is hard to even make sense of the statement that only structure exists without metaphysics.

6.3.1.1 Varieties of Ontic Structural Realism: Objects, relations and dependence

Traditionally objects have been seen as fundamental; there is debate on which properties or relations (if any) are to be counted as non-supervenient or fundamental alongside objects. These views do not constitute Ontic Structural Realism because they allow objects to exist independent of their place in the structure of the world. Ontic Structural Realism does not.

There are various ways of cashing out the ontological dependence between objects, properties and relations in Ontic Structural Realism. It is worth noting that ontic structural realists generally do not talk about properties in the traditional sense. Rather, they talk about structures. According to Esfeld, "Structures are properties, too, in a broad sense of the notion of properties, namely relations instead of intrinsic properties, requiring more than one object in order to be instantiated." (2009, p. 184)

Ontic Structural Realism takes relations to be fundamental. This leaves some room for wiggle regarding the status of objects. There are at least three different ways of cashing out the ontological dependence between relations and objects in Ontic Structural Realism in the literature:

1) Relations are fundamental. There are no objects. We may use the notion of objects to navigate everyday life but ultimately all there is is structure.
2) Relations may be ontologically primary, with objects being ontologically secondary or dependent on the relations. Objects are no more than nodes in a structural web.
3) Both objects and relations may be fundamental. In this case, there is no ontological priority of one over the other (Esfeld and Lam, 2011, pp. 145-7).

The first position is eliminative about objects. The second takes relations to be ontologically primary and objects to be dependent on them. The third rejects ontological priority claims between objects and relations. Rather these are symmetrically dependent on each other.

Ontic Structural Realism is generally associated with the first two positions which are eliminative or deflationary about objects. Ladyman and Ross (2007) and French (2014) have written the most prominent books on Ontic Structural Realism. They both endorse these sorts of views. I will start with a note on Ladyman and Ross's position, although I set these authors aside after to focus on others who are more engaged with the metaphysics of the view.

Ladyman and Ross endorse position 2, that objects depend on relations. They characterise Ontic Structural Realism as the view that "the world has an objectively modal structure that is ontologically fundamental, in the sense of not supervening on the intrinsic properties of a set of individuals." (2007, p. 130). This is important as the modal nature of Ontic Structural Realism will reappear as a key motivator for this view, in French (2014) and Esfeld and Lam's work (Esfeld, 2009; Esfeld and Lam, 2011).

Ladyman and Ross are highly motivated by the scientific case for Ontic Structural Realism. They take the physics to undermine traditional objects. The underdetermination of the individuality of objects motivates their move to a purely structural – or relational – world. This breaks the underdetermination by negating that

objects exist over and above the structure we can learn about. Nonetheless, Ladyman and Ross do not eliminate objects entirely. In their words: "there are objects in our [Ladyman and Ross's] metaphysics but they have been purged of their intrinsic natures, identity, and individuality, and they are not metaphysically fundamental." (2007, p. 131) Objects exist as nodes in structure, they are not fundamental but dependent on the fundamental relations or structure.

French, possibly the most famous advocate of Ontic Structural Realism, has advocated for the eliminative version - 1. He believes that the world is an elaborate structural network, nothing else. Objects are a mere *façon de parler*. Talk of objects helps us navigate everyday life but is not scientifically robust. In French's words, we ought to commit to the "structures underpinning quantum statistics and reconceptualise (or eliminate) our putative objects in terms of this structure." (French, 2014, p. 43) A detailed explanation of this is beyond the scope of this chapter. French himself says that much of his book was required to expand on this notion (ibid). I will revisit French's work in 6.3.3 where I look at why he says that Ontic Structural Realism is a reverse-engineering of Dispositional Essentialism and I look at the positive metaphysical system he proposes.

Esfeld (2004, 2009) and Lam (Esfeld and Lam, 2011) roughly argue for position 3 but with a caveat. They believe that the distinction between objects and relations is not an ontological one but a conceptual one. This is an intuition shared by French although his view is eliminative whereas theirs is not (Esfeld and Lam, 2011, p. 150). As we shall see, they believe that objects cannot exist without relations and vice versa. In that sense they depend on each other for existence. In the next section, I will look at what led them to this position. I will now show why Esfeld argues that Ontic Structural Realism shares the motives of Dispositional Essentialism, and how that must inform the understanding of the view for it to be successful. This will help us understand the strength behind Esfeld and Lam's Ontic Structural Realism.

6.3.2 Esfeld's Ontic Structural Realism

According to Esfeld, the arguments for Dispositional Essentialism apply to Ontic Structural Realism. In particular, Dispositional Essentialism is argued for on the basis that it avoids quidditism and humility about properties. It does this by making those properties inherently modal. Similarly, Esfeld argues that, if Ontic Structural Realism

is to work as a form of realism, the structure must be causal. In the next subsections, I will look at the motivations for Dispositional Essentialism, followed by the motivations for Ontic Structural Realism and why Esfeld says they overlap. Finally, in the last subsection I will look at Esfeld's proposed ontology for Ontic Structural Realism.

6.3.2.1 The motivations for Dispositional Essentialism

To recap, the two main contenders for how we view properties are Categoricalism and Dispositional. According to the first, properties have no essential modal features. According to the second, properties have essential modal features. Properties are dispositions to certain manifestations.

Within Categoricalism properties are identified by their quiddity or primitive character that makes them different from any other property. Properties have a transcendent identity which is independent of the causal roles they play. David Lewis who championed this view saw what properties do – the roles they play – as contingent (Lewis, 1986; Miller, 2004). In our universe charge happens to act in accordance with Coulomb's law. Like charges repel each other, opposite charges attract each other. However, in another universe mass might happen to behave this way and charge might act differently. Just the fact that we can imagine these two switching roles is taken to show that their roles are not essential to them.

Dispositional Essentialism, the alternative view, takes properties to be dispositions to certain manifestations (Bird, 2007; Vetter, 2015). It is in charge's nature to repel an object with the same charge and attract an object with the opposite charge. This is what we mean when we say an object is charged. Further, dispositions are how ordinary folk and scientists acquaint themselves with properties. When we imagine worlds where mass does what charge does (and vice versa) we are really imagining a world where we switch the names of mass and charge Two strong motivators for this view, which feature heavily in Esfeld's work, are the fact that it avoids the quidditism and humility present in Categoricalism.

Quidditism, as we saw, is the view that properties possess an intrinsic aspect or nature. This primitive character is independent of and separate from their modal profile. Even on the thinnest conception of quiddities – as the distinct numerical identity of properties – this is divorced from the modal role the property possesses (Locke, 2012). What

properties are and what they do are not linked. Humility follows from quidditism. Within Categoricalism we can never acquaint ourselves with the nature of properties. We can only know the causal relations properties enter into in our world but these are contingent. They are not of the essence of the properties in question. We can never truly identify or know a property because we do not have access to its quiddity. Thus, we are left epistemically humble, unable to know properties (Lewis, 2006; Esfeld, 2009). Let's see how this fits with Ontic Structural Realism.

6.3.2.2 The motivations for OSR

Earlier in this chapter we looked at the scientific arguments for Ontic Structural Realism. However, in this section we will look at the metaphysical case for the view. Metaphysical arguments for Ontic Structural Realism make the case that this view avoids conceptual issues of competing views, offering a better metaphysical package. As we shall see, this view is thought to close the gap between our epistemology and metaphysics, avoiding Newman-type objections.

The gap between epistemology and metaphysics, refers to the gap between what we can know and what there actually is. Epistemic Structural Realism leaves this gap open. On this view, we can only know the structure of reality but remain ignorant of its nature. This position has led to objections like Newman's objection, that if all we know is structure, we do not know much about the world at all. At best we know the number of things that realise the structure and the abstract relations between them, however we remain entirely clueless about the ultimate nature of reality.

This gap between the epistemology and metaphysics of Structural Realism is reminiscent of the problems for Categoricalism – quidditism and humility - mentioned above. In both cases there is a divide between the knowable (the structure or behaviour of properties) and the nature of the thing in question. In both cases we are left ignorant or humble to the nature of the universe on the basis that we simply can't access the essence of the things in question (Esfeld, 2004, p. 614).

A gap between metaphysics and epistemology appears in all views which allow us to know the full relational profile of reality without knowing anything at all about its intrinsic nature i.e. Categoricalism and Epistemic Structural Realism. Naturally, there is a parallel to draw between the case for the alternative views which solve the problem

– Dispositional Essentialism and Ontic Structural Realism. Dispositional Essentialism solves the problem of quidditism and humility about *properties* by taking the relational to reflect the intrinsic nature of reality. The behaviour of properties reflects what those properties are. Ontic Structural Realism does something similar regarding the concrete world and concrete objects. It gives a new level of reality to the structural. The structure of the world is the world. A concrete object is its structure. There is nothing else to it. So, by knowing the structure of the world, we know the world. The gap is closed, and humility is avoided.

Epistemic Structural Realism says that our knowledge of the world is in principle limited to its structure, with its nature being hidden to us. Ontic Structural Realism accepts the first part – that our knowledge of the world is structural. However, it rejects the second part – that the nature of the world is hidden from us. Ontic Structural Realism takes the structure to be all that there is to know, and all that exists. The idea of transcendent identity for individuals or categorical basis are met with suspicion. As we shall see in the next section, Esfeld thinks that for this view to be a truly successful form of realism, that structure will have to be causal structure or else the gap remerges.

6.3.2.3 Esfeld and Lam's Ontic Structural Realism

Esfeld's Ontic Structural Realism is both inspired by the scientific arguments and metaphysical arguments for this view. On the scientific side, he writes amply about the entangled nature of reality (2004). On the metaphysical side, he is motivated to close the gap between epistemology and metaphysics allowing us to know the intrinsic nature of reality via its structure. In this section I will look at Esfeld and Lam's proposed ontology for Ontic Structural Realism.

Esfeld and Lam's Ontic Structural Realism is moderate (Esfeld 2004, 2009; Esfeld and Lam, 2011). It aims to be the least metaphysically revolutionary it can whilst accommodating the arguments for Ontic Structural Realism. In what follows we will see why Esfeld and Lam (ibid) reject radical or eliminative Ontic Structural Realism. We will see why they argue that objects and relations are both fundamental and symmetrically dependent, as well as what that looks like for them. In addition, we will revisit the parallels between the arguments used for Dispositional Essentialism and Ontic Structural Realism and see why Esfeld argues that the structure of the world is causal (2009).

Radical or eliminative forms of Ontic Structural Realism have received a lot of criticism. The idea that there could be relations without relata (objects which stand in those relations) is baffling. Additionally, Esfeld and Lam (2011) point out that this situation is not much better for philosophers who allow objects but claim that these are ontologically dependent or secondary to relations. This is because, at the fundamental level, they still have relations without relata. However, ontic structural realists are often moved to make relations fundamental, and objects secondary or mere *façons de parler* for the scientific arguments we looked at above.

As we saw the individuality of objects is underdetermined by science. According to the principle of identity of indiscernibles, if two objects share all the same properties, they are one and the same object. We cannot differentiate quantum objects via their properties. All electrons have the same mass, spin and charge. Further, it is hard to differentiate them spatiotemporally. Additionally, they do not follow regular statistics. They follow special statistics which do not count permutations of electrons as separate states (see section 6.2 for more details). Their individuality is highly debated in light of this.

The fact that quantum physics underdetermines the individuality of objects has led ontic structural realists to be deflationary or eliminative about objects. Philosophers like Ladyman and Ross (2007) take objects to be ontologically secondary, with some like French eliminating them altogether (2010, p. 14). However, Esfeld and Lam argue that this does not warrant making relations prior to objects. We still quantify quantum objects. For instance, if two electrons are entangled, we know that there are two electrons standing in that relationship. That does not mean that they have transcendent individuality, however it leaves the status of objects relative to relations open. The science does not favour a particular reading of priority dependence between objects and properties (2011, p. 150).

To avoid these issues, Esfeld and Lam propose that the distinction between objects and relations/properties is not an ontological one but rather a conceptual one "anchored in our thinking and language" (2011, p. 150). Interestingly, French says something similar (2010, p. 18). He agrees that the distinction between objects and relations is conceptual. However, where Esfeld and Lam are drawn to a more moderate view, French endorses radical Ontic Structural Realism, eliminating objects altogether.

Esfeld and Lam sum up their view on the relationship between properties and objects in what follows:

> "Following Spinoza's Ethics (1677), properties are modes, that is, concrete, particular ways in which objects are. There is no ontological distinction between objects and their properties in the sense of modes: the modes are the way in which the objects exist. Objects do not have any existence in distinction to their ways of existence, and their ways of existence do not have any existence in distinction to the objects. One can draw a conceptual distinction between objects and their ways of existence, but not an ontological one, applying to reality. In reality, there is only one type of entity, namely objects that exist in particular ways." (2011, pp. 150-1)

The structure of the world intermeshes and entwines in many complicated ways. Some of these give rise to what we see as objects. We are able to abstract away certain ways those objects are, comparing them, this explains our talk of properties. However, for Esfeld and Lam, these two are not separable in reality. We cannot have a property-less object or a property which isn't "had" by anything. All things are certain ways, all ways are ways that something is. In this sense they depend on each other for their existence.

Moderate Ontic Structural Realism still breaks with traditional ontology in many ways. This is especially worth emphasising given the fact that Dispositional Essentialism plays such a prominent role in motivating the view. Esfeld's dispositional essentialist motivation should not be taken to mean that his view ends up being a sort of dispositionalism with a dispositional causal structure.

As mentioned previously, Dispositional Essentialism does not tend to require a revisionary metaphysics. Many dispositional essentialists explicitly take the view that properties are universals (Bird, 2007; Mumford, 2004). None that I know of reject traditional objects. Esfeld and Lam's Ontic Structural Realism breaks with metaphysical tradition and traditional ontology in many ways. First, they allow mutual dependence between properties and objects. The reality of these two is entwined to the point that they are only separable in thought – not reality. Mutual ontological dependence (though I defend it in the next chapter in the case of properties and laws) is usually frowned upon. Most philosophers tend to think that there must be one thing which grounds the other, so the explanation runs in a particular direction.

Second, traditional metaphysics revolves around how to conceptualise and relate universals and particulars. The distinction between these two categories is taken to be ontological and seldom questioned. Yet, Esfeld and Lam (2011) are forthcoming in saying that their metaphysics does not leave room for such ontological categories. "As with any metaphysical position, there is a certain price to pay in order to make this position available. One has to abandon the view of properties being universals that are instantiated by particulars, that is, objects." (p. 151) After all, they do not endorse a metaphysical distinction between these two. However, in their view this is a small price to pay as the distinction between universals and particulars has been debated for thousands of years without becoming much more intelligible (p. 151).

Finally, Esfeld and Lam may accept objects in their ontology, but this involves a significant revision to our understanding of objects. Not only are they dependent on the relations, but they are not individuals. In their view, there is no transcendent individuality of objects. Nothing differentiates one object from another (2011, p. 152). They accept a numerical plurality of objects but that is about it.

As we saw in earlier sections, Esfeld drew a strong parallel between the motivations for Dispositional Essentialism and Ontic Structural Realism (2009). This parallel further informs his view of what Ontic Structural Realism is, or should be, in order to work. According to Esfeld, just like properties cannot be categorical if we are to know them, the structure of the world must be causal for us to know it.

> "ontic structural realism has been conceived notably by Steven French and James Ladyman as a position that is able to vindicate a certain form of scientific realism with respect to fundamental physics. Against that background, the claim of this paper is that ontic structural realism is suitable as a form of scientific realism only if it commits itself to causal structures, that is to say, only if the essence of the fundamental physical structures is taken to consist in the power to produce certain effects. If, by contrast, the fundamental physical structures are regarded as being categorical, a commitment to scientific realism in the sense of the fundamental physical theories (the current ones, or some future successors of them) being in principle able to reveal the real constitution of the fundamental physical structures is blocked by the fact that the whole domain of causal relations—and consequently the whole domain of observable phenomena—may

> as well supervene on other fundamental physical structures than those ones admitted by any of the past, current or future physical theories." (2009, p. 188)

In sum, Ontic Structural Realism is based on what science tells us about fundamental physics. However, if it were to commit to mathematical or abstract structure alone, it would fail at this. If the structure is abstract it is in a sense Categorical. We do not truly know the nature of reality – which is blocked from our epistemic access. The gap between epistemology and metaphysics reopens and we may be forced back to the kind of Structural Realism Newman got his hooks into. Esfeld concludes that for Ontic Structural Realism to function it must bring the structure into the empirical realm. The structure is causal.

I find Esfeld (and Lam)'s work on Ontic Structural Realism compelling in many regards. They appreciate the similarities between the case for Dispositional Essentialism and Ontic Structural Realism as ways to avoid quidditism and humility and bridge the gap between epistemology and metaphysics. This in turn affects what kind of Ontic Structural Realism they endorse. To truly avoid quidditism and account for causation and the concrete structure of our universe, the structure must be causal. These ideas will be revisited in my next chapter where I forward my own view, which is a sort of hybrid between Dispositional Essentialism and Ontic Structural Realism. It will differ from Esfeld and Lam's in many ways, particularly in their take on objects – my concern is more with properties and laws. However, my view of the relationship between properties and laws will take some influence from their view on properties and objects as ontologically dependent.

6.3.3 French's Ontic Structural Realism

6.3.3.1 Ontic Structural Realism as a reverse-engineering of Dispositional Essentialism

A major selling point of Dispositional Essentialism is the promise of an elegant framework for explaining laws. Laws are necessary consequences of the dispositions of properties. As the dispositions of properties are fixed, the laws are fixed too. So, within Dispositional Essentialism, laws are necessary – they necessarily follow from the nature of the properties they are about. Thus, laws supervene on properties. The dispositions of properties entail the laws. Any world with charge will be a world where Coulomb's law

applies. After all, Coulomb's law outlines how charged objects interact, and this is grounded in the nature of charge itself.

Ontic Structural Realism, like Dispositional Essentialism, aims to give a robust account of modality avoiding the likes of quidditism, humility and regularity views of laws. French makes the first step towards this by elaborating on the notion of structure within his view. He claims that the structure of the world is inherently modal (2014, p. 263). Further, he takes laws and symmetry principles to be the fundamental constituents of this structure.

Dispositional Essentialism is a properties-first, laws-second view. How does this compare to Ontic Structural Realism and why does French claim that Ontic Structural Realism is a reverse-engineering of Dispositional Essentialism?

Recall, in chapter 3 we saw that Jessica Wilson (2012) argued that we need determinables in our ontology to account for modality. By determinables Wilson meant determinable *properties*. Properties like charge or mass are determinable relative to their determinates – particular charges or masses – as they are more general. They cover all possible determinates and are the sorts of properties we see featured in laws like Coulomb's law or the law of gravitation which outline how charge and mass behave generally. The idea is that determinable properties explain why these high-level laws occur. Without them, something is left out of the picture. French cites Wilson and is persuaded of the need for determinables. He argues that we need determinables to be part of the fundamental ontology of the world (French, 2014, p. 284). However, by determinables he means determinable laws and symmetries (Ibid, p. 290) *not* properties (confirmed by personal correspondence).

On French's view laws and symmetry principles form the basic structure of the world. Properties depend on these. So, properties are secondary to the modal structure. He sees this position as quite close to Dispositional Essentialism. Whereas Dispositional Essentialism is a properties-first, laws-second view; Ontic Structural Realism places laws and symmetries first, seeing properties as ontologically secondary. French sums up the relationship between these views by saying that his Ontic Structural Realism is a reverse-engineering of Dispositional Essentialism, in his words:

> "by reverse-engineering dispositionalism, we are led naturally to the structuralist view. So, whereas the dispositionalist takes the laws to arise from or be dependent in some way upon the properties… I shall invert that order, taking the properties to be dependent upon the laws and symmetries. Because of this inversion, I have to relocate the modality, shifting it along the line of dependence from the properties to the laws and symmetries themselves." (French, 2014, p. 264)

I will look at the nature of his fundamental base – and how he accounts for the concrete structure of our universe – in section 6.3.3.3. Before I advance, I must address a quick concern for his view that Ontic Structural Realism is a reverse-engineering of Dispositional Essentialism. Ontic Structural Realism puts laws *and symmetries* first and properties second. Dispositional Essentialism puts properties first and laws second. What is missing? Dispositional Essentialism makes no mention of symmetries of course! In order to appreciate the full sense in which Ontic Structural Realism is a reverse-engineering of Dispositional Essentialism we must appreciate that there is no gap here. As discussed in chapters 4 and 5, Dispositional essentialists expect to explain symmetries via properties as they would any other law. They would either do this by explaining them away as by-products or meta-statements about other laws (Bird, 2007, p. 214) or by seeing them as laws which must be explained by reference to properties of natural kinds or systems (Bigelow, Ellis, Lierse, 1992; Chakravartty, 2019). Alternatively, I proposed that they could be accounted for via collective properties. All these possibilities share a feature – they explain global principles via properties, be they properties of quantum objects or natural kinds. Thus, for the purposes of comparing Dispositional Essentialism and Ontic Structural Realism's accounts of modality, the term "law" can be used liberally here to include symmetry laws.

Dispositional Essentialism and Ontic Structural Realism both aim to ground modality in the fundamental ingredients of the world. Further, they both use the same categories - properties and laws - in their attempts to do so. However, they take opposite stances on which of these is fundamental and which is dependent.

As such, it would appear that the main difference between how these views account for modality is the direction they take the dependence between properties and laws to go in. Chakravartty illustrates this point by differentiating Dispositional Essentialism from Ontic Structural Realism by saying that the former has a bottom-up approach to reality

whereas Ontic Structural Realism has a top-down approach (2019, p. 15). As a result, the success of either depends on the persuasiveness of taking the one to be fundamental over the other. In other words, the success of either view depends whether the case for a bottom-up or top-down approach to modality is more convincing.

Next, I will look at the reasons we might have to prefer Dispositional Essentialism or Ontic Structural Realism's accounts of modality. I will be particularly interested in French's case for favouring Ontic Structural Realism i.e. French's case for taking laws (as opposed to properties) to be fundamental. He argues that Dispositional Essentialism's properties-first approach fails to ground modality. As a result, his view emerges victorious. I show the case for both views. And, in the next chapter, I will argue that we have no reason to prefer the ontological dependence to go one way rather than another. However, in what follows I will highlight the importance of determinables for Dispositional Essentialism and Ontic Structural Realism's ability to account for modality. This further pushes the similarities between their metaphysics. Finally, I end this section on French by giving some more detail to his metaphysics and spelling out what role properties have in his Ontic Structural Realism.

6.3.3.2 Ontic Structural Realism vs Dispositional Essentialism

French argues that Dispositional Essentialism falls short of its goal of accounting for modality and avoiding regularity views of laws. In sum, the bottom-up approach does not work. In his view, we ought to abandon Dispositional Essentialism in favour of Ontic Structural Realism, placing the modality at the law level. This is the only way to truly ground modality and avoid regularity views of laws. He conceptualises the problem in terms of determinables and determinates. The issue for French is that laws are determinable (or general) where properties are determinate. I will proceed to explaining why French holds this view. I will show that his argument is most successful against Bird-style Dispositional Essentialism. It need not cut ice with the modified Dispositional Essentialism I proposed in chapter 3. I will then show what we can learn from these arguments, paving the way to later discussions of my hybrid view.

The difficulty for traditional Dispositional Essentialism is that contemporary physics is built out of functional laws. Here I follow Armstrong in taking a functional law to be "a determinable law that governs a class of determinate laws." (1997, p. 245) There are various ways of conceptualising the determinable-determinate relationship (I discussed

the issue in 3.6 and will go into more detail in 7.4). For instance, determinables are often viewed as sets of determinates. Alternatively, determinables may be seen to differ from determinates in terms of specificity. So, determinates are more specific than determinables. Either way we can get a sense of what determinables and determinates are by example. Red is a determinate of colour, however it is also a determinable of scarlet and crimson. Similarly, quadrangle is a determinate of shape, however it is a determinable of square and rectangle. As a result, a *determinable law* will be one that holds at the determinable level (for instance a law that's true of colour) and a determinate law will hold at the determinate level (in this case red, blue or yellow).

French's criticism is lodged at traditional Dispositional Essentialism, which takes ordinary properties to ground general laws. It is especially damning in light of Bird's popular exposition of the view in *Nature's Metaphysics* (2007). As we saw, Bird takes "pure" or fundamental dispositions to be single-track. That is, fundamental dispositions are characterised by a single stimulus and manifestation condition (2007, p. 21). We can infer that laws regarding single-track dispositions will be fundamental. These will be laws of the type $\forall x((Px \wedge Sx) \rightarrow Mx)$ where a determinate property, taken with a determinate stimulus give rise to a determinate manifestation. So only determinate properties are fundamental. These directly ground equally determinate laws. However, science is not built on determinate laws relating determinate properties (Vetter, 2012).

Determinate laws would give us little information about the world, only outlining the behaviour of maximally specific and previously studied properties. Science is concerned with determinable laws and properties (for a full explanation of this kind of laws see section 2.3.1 entitled "functional laws"). As these are multi-track or "impure", Bird would take it that these laws are not basic and are mere conjunctions of determinate laws which are grounded in determinate properties. This leaves the determinable laws of current science as brute regularities among determinate laws, which would mark a failure of the explanatory aims of Dispositional Essentialism to ground all modality in properties.

Bird-like Dispositional Essentialism is left in an awkward position. The fact that all determinate charges behave in similar ways, so similar that their behaviour is predicted by a single equation, calls out for an explanation. In light of Dispositional Essentialism's seeming inability to account for determinable laws, French argues that we should take those determinable laws to be fundamental. This is supposed to be the only way of

avoiding the regularity view. Thus, French invited those inclined towards Dispositional Essentialism to abandon their view in favour of Ontic Structural Realism (2014, p. 264). However, as we saw, determinate-only Dispositional Essentialism is not the only option on the table.

French's objection is lodged at a specific form of Dispositional Essentialism. To be fair, that is the standard kind of Dispositional Essentialism in the literature. However, in chapter 3 I argued that Dispositional Essentialism can weasel its way out of the problem of accounting for function laws by introducing determinable properties into its ontology. If we are realists about determinable properties, and allow those properties to be dispositional, there is much less mystery surrounding how we come to have determinable laws. Determinable laws are about determinable properties, from a dispositional properties-to-laws perspective, the determinable properties ground the determinable laws. We see this even with regards to global principles, which may well be the hardest laws to account for (see chapters 4 and 5 for my proposal of how to accommodate them within Dispositional Essentialism).

The take home message here is how vital determinables are in accounting for modality from a structuralist or dispositionalist perspective. This will be key to my view, which is hybrid between Dispositional Essentialism and Ontic Structural Realism's views of modality. As we saw, Dispositional Essentialism requires determinables to truly account for modality (Wilson, 2012; chapter 3). Laws are determinable, so we require determinable properties to account for them. On the ontic structural realist side, French readily accepts Wilson's point about the need for determinables to account for modality. However, he understands determinables to be laws. Later, I will argue that determinable laws require determinable properties and vice versa. For now, I underscore the importance of fundamental determinables.

6.3.3.3 The relationship between properties and laws in Ontic Structural Realism

Ontic Structural Realism tends to be eliminative or deflationary about objects. We know that French is eliminative about objects (2014; Cei and French, 2011), but what about properties?

French's stance on properties can be confusing. He sends mixed messages. These mixed messages are interesting to track as they shed light on different facets of the

relationship between properties and laws. On the one hand, as we saw, French takes laws to be fundamental and properties to be secondary. This is witnessed in various places. Like when he says that he inverts Dispositional Essentialism by "…taking the properties to be *dependent* upon the laws and symmetries." (2014, p. 264, emphasis my own) He also says:

> "I see physics as having provided an inventory of laws and symmetries—that is, features of the structure of the world—with properties, sparse or otherwise, as a kind of *metaphysical by-product*, and take these laws and symmetries as both determinables in themselves and as elements of the fundamental base of the world." (ibid, p. 285, emphasis my own)

He always talks about determinables – laws and symmetries – as fundamental. Then he uses terms like "dependent" or "by-product" to refer to properties. This paints a very clear picture. Laws are fundamental and properties are dependent on them. However, this is not the full picture.

In other parts of his work, French clearly states that reality is not merely determinable. More to the point, he states that the fundamental level cannot be purely determinable. If it were, there would be no way to differentiate the actual world from other possible worlds, with a different instantiated structure but the same laws.

French's proposal is that the fundamental level of reality is composed of both determinates and determinables. We saw that by determinables he meant laws and symmetries. By determinates he means properties. These act as initial conditions or 'existential witnesses' to determinates. In his words:

> "…given the inherent modal nature of the laws and symmetries it cannot be the case that the fundamentality base of this, the actual, world is entirely determinable. Here the determinates act as 'existential witnesses' for the determinables in that they are indicative of the non-modal aspect of the latter. Thus it is determinables plus determinates that form the fundamentality base and in this world that base is composed of groups and the relevant representations together with laws plus the relevant initial conditions." (French, 2014, p. 290)

So, while French at times appears to brush away properties as ontologically secondary, they clearly play an important role in his ontology. He echoes Wilson (2012) when he says that we need both fundamental determinables and determinates in our ontology. Fundamental determinables account for the modal aspects of reality. Fundamental determinate properties act as 'existential witnesses' to the determinables. Without this second part the fundamental level of reality would not account for what is instantiated i.e. anything that concretely exists or happens in our world.

Finally, French acknowledges that some may find his inclusion of instantiated properties or initial conditions inconsistent with Ontic Structural Realism. There is a concern that introducing determinates into one's ontology is to introduce a non-structural element. However, he says that if the project of structuralism is to have a completely determinable ontology it is "made of straw" (2014, p. 286/7). Indeed, this objection seems to be based on the idea that structure refers to purely abstract or mathematical structure. Yet, an ontology based on that kind of structure alone would not work. We need to be able to differentiate between concrete and abstract structure somehow. Indeed, French does not see determinates as non-structural but as giving data on the concrete, instantiated, structure of the world. These are needed to get a full picture and to differentiate the actual world from other possible worlds (ibid).

6.3.4 Chakravartty's perspective on the debate between Dispositional Essentialism and Ontic Structural Realism

Chakravartty has said a lot about Structural Realism and Dispositional Essentialism, some of which was mentioned already, particularly in the global principles chapters. For the purposes of this chapter I will look at his arguments in *Physics, Metaphysics, Dispositions, and Symmetries – à la French* (2019). In this paper he assesses the differences between Dispositional Essentialism and Ontic Structural Realism. He argues that French's reasons for preferring the structuralist position fail. The science does not deliver a verdict either way.

Dispositional Essentialism and Ontic Structural Realism are in the business of accounting for modality. Dispositional Essentialism places the modality at the property level: fundamental properties give rise to laws. Ontic Structural Realism does the reverse: laws and symmetries are fundamental, properties are derivative. Chakravartty agrees with this much. He characterises Dispositional Essentialism as having a "bottom-

up" approach to reality whereas Ontic Structural Realism has a "top-down" approach (2019). He then teases out the reasons why French prefers his top-down approach.

We already saw one reason for preferring a top-down approach. In French's view determinables (laws and symmetries) are better suited to ground modality than properties (determinates). In chapter 3 I argued that Dispositional Essentialism could follow French (2014) and Wilson (2012) in introducing fundamental determinables, with the caveat that these are fundamental determinable *properties*. In fact, this seems like a more natural way to go. Talk of determinables generally refers to determinable *properties* (Wilson, 2012). The fact that French takes determinables to be laws seems rather odd considering that determinable act as shorthand for determinable properties. Regardless, French has a response to this move.

French would counter that global principles cannot be accounted for via properties. At the very least, he would argue that taking global principles as fundamental is better than what the dispositional essentialist does (French, 2014). At the time of French's book, the world-kind hypothesis was the only option for accounting for global principles in the dispositional essentialist literature. However, as we saw in chapters 4 and 5, there are new (and I argue improved) ways of accounting for global principles these days. In particular, Chakravartty (2019) has suggested that systems have properties. Briefly, he argued that there is much warrant for and talk of systems and their properties in science, so this is not *ad hoc*. Further, I forwarded another solution. I argued that objects can collectively share properties. This is even more parsimonious than Chakravartty's approach as it does not postulate high-level entities at all.

French would maintain that Ontic Structural Realism's account of modality should be preferred because it is a better view for reasons I will soon give. Likewise, a dispositional essentialist would claim the reverse. There is no clear victor when it comes to accounting for modality. Both views are responding to the same scientific evidence, and neither is clearly more parsimonious or less *ad hoc* than the other. However, until now I have only considered whether these views are able to account for modality. There is a wider story. If we take a step back at look at the whole picture there are bigger reasons for preferring one view over another. These reasons get to the core of French's preference for the top-down, ontic structural realist, approach.

Dispositional Essentialism retains a traditional ontology. At the fundamental level there are dispositional properties and the objects which bear them. Those properties give rise to laws. French's fundamental level has laws, symmetries and properties. There are no objects. Objects are eliminated from his ontology altogether (2010, 2014). French's ontology is appealing because it is supposed to be more parsimonious and to give a neater explanation "read off the science" so to speak. However, Chakravartty contests the idea that Ontic Structural Realism is "read off the science" (2019).

As we saw, physics puts traditional objects under duress. Objects are entangled. Reality may be non-separable and holistic. Quantum objects cannot be differentiated by their properties or spatio-temporal location. These objects obey odd statistics. The principle of permutation invariance tells us that there is no difference between electron A being in box A and B in box B, and electron B being in box A and electron A being in box B. In quantum statistics permutations of electrons count as one and the same event, not two distinct events. Scenarios which only differ with regard to electron permutation are weighed as one single possibility. The science leads French to be eliminative about objects. However, Chakravartty argues that the science does not deliver decisive blows either way.

Science does not point to the elimination of objects. It underdetermines the individuality of objects. These are two very different things. "A lot hangs here on what one means by 'object'. For instance, French often writes as though it is a truism that the concept of any given object, in order to have genuine content, must include some information regarding whether it is (or is not) an individual." (Chakravartty, 2019) However, this need not be the case. There is increasing awareness of the literature and caution in the use of the term "object". While some philosophers will continue to cling to classical objects, this is not true for all.

Chakravartty points out that Dispositional Essentialism is not at odds with the science provided it takes the term object with a pinch of salt. In Chakravartty's words, the physics does *not* suggest "an obvious problem for the idea that less-restrictively-conceived objects have properties, some or all of which may be dispositional." (2019, p. 12) The science undermines classical objects, leaving their identity underdetermined. The move to eliminate objects is a controversial one. French adopts this but we need not. The science does not deliver a knockout blow for either view. For my part, I do not aim to settle the issue of objects in this thesis – that is far beyond the scope of this project.

Nonetheless I make sure the view I forward next is compatible with multiple conceptions of objects and not reliant on outdated understandings of objecthood.

Conclusion:

Until now Dispositional Essentialism was our focus. In this chapter, I introduced Ontic Structural Realism. There is a strong case for this view. It has a substantial history, with roots in early 20th century epistemic structural realists who argued that we only know the structure of the world, not its nature. Ontic Structural Realism takes structuralism to a new level, arguing that all there is is structure. In the first half of the chapter we looked at the many scientific and metaphysical reasons for this controversial view.

Dispositional Essentialism and Ontic Structural Realism keep very different company. However, we saw that there is a growing awareness of the proximity between these views. Both stem from a desire to explain modality. Both aim to avoid quidditism and humility, they reject Categoricalism or quidditism in attempts to close the gap between epistemology and metaphysics.

Ontic Structural Realism comes in various flavours or degrees. I have not been concerned with the most radical forms of Ontic Structural Realism here. Rather, I have looked at intermediate and moderate versions. In particular, I have looked at the work of those who compare Dispositional Essentialism and Ontic Structural Realism as these authors tend to give the most detailed metaphysical pictures of Ontic Structural Realism anyway. This sets the scene for the next chapter where I forward my own view. It is a sort of hybrid between Dispositional Essentialism and Ontic Structural Realism. Before I delve into my hybrid view, I close this chapter with a nod to what I have learnt from these authors and a hint of what I take from them in what is to come.

First, we saw that Esfeld and Lam (Esfeld, 2004 and 2009 and Esfeld and Lam, 2011) argued that if Ontic Structural Realism is to avoid quidditism and humility, and really close the gap between epistemology and metaphysics, the structure cannot be abstract. They argue that it must be causal. They also view objects and properties as separable only in thought. Although I am less concerned with objects, we will find traces of their

argument in the next chapter where I argue that there is a good argument for the metaphysical interdependence of properties and laws.

Second, I looked at French's work (2010, 2014). He argued that Ontic structural Realism was a reverse-engineering of Dispositional Essentialism. Where Dispositional Essentialism puts properties first and laws second, Ontic Structural Realism puts laws first and properties second. Chakravartty puts this in a new light, saying that Dispositional Essentialism gives a bottom-up (from properties to laws) account of modality where Ontic Structural Realism's is top-down (from laws to properties). On his view (contra French) science cannot dictate which we choose. Finally, French deals with the issue of accounting for the concrete universe by saying we need determinable (laws) and determinate (properties) in our ontology.

In some ways my view will differ the most from French's. At the same time, I will borrow liberally from his conceptual framework (and on Chakravartty's pushback). They argue about whether a bottom-up or top-down approach is better – whether properties or laws come first. I argue that neither is the case. In the next chapter I make my case for the symmetric dependence of properties and laws. I show that if we are structuralists, we have good reason to abandon both Dispositional Essentialism and Ontic Structural Realism in favour of a hybrid view with less hierarchy.

7. Dispositional Essentialism and Ontic Structural Realism: a hybrid view

Dispositional Essentialism and Ontic Structural Realism both aim to ground modality in our fundamental ontology. Thus far this thesis has focused on their individual methods for doing so. We have seen that there are important similarities between their approaches which make Dispositional Essentialism and Ontic Structural Realism closer than they might first seem. Dispositional Essentialism takes properties to be fundamental and laws to be dependent. Ontic Structural Realism takes laws to be fundamental and properties to be what needs explaining (French, 2014). Hence, French claims that Ontic Structural Realism is a reverse-engineering of Dispositional Essentialism (ibid). Alternatively, Chakravartty claims that Dispositional Essentialism has a bottom-up approach to modality whereas Ontic Structural Realism's approach is top-down (2019).

In this chapter I forge a middle ground – a hybrid between Dispositional Essentialism and Ontic Structural Realism. My hybrid view takes properties and laws to be mutually dependent on each other. I begin by talking about ontological dependence in section 7.1. Then, I return my focus to Dispositional Essentialism and Ontic Structural Realism. In 7.2 and 7.3, I fill in some gaps left by these views. Both aim to explain modality via determinate properties and determinable laws. I argue that both ontologies leave gaps. I argue that, in order to fill those gaps, determinate laws and determinable properties need to be let into the fold. In 7.4, I address lingering issues for our understanding of determinates, determinables, and the relationship between them.

In 7.5 I argue for my symmetric dependence view. I argue that symmetric dependence provides the best framework for understanding the relationship between properties and laws in dispositionalism and structuralism. These views reject the transcendent individuation of properties so that properties are relationally individuated by the laws they enter into. At the same time, laws are relations between properties. I use this to show that the quest to determine whether properties are fundamental (Dispositional Essentialism) or laws are fundamental (Ontic Structural Realism) is misguided. Neither can be prior to the other. Properties and laws depend on each other for their identity and existence. They are equally fundamental and mutually dependent.

Finally, in my concluding section, I recap my hybrid view and tie up some loose ends. I argue for the symmetric dependence of properties and laws. I see this as a merger view or hybrid between Dispositional Essentialism and Ontic Structural Realism with respect to modality. My hybrid view is able to incorporate the dispositional essentialist insight that laws depend on properties. It also makes sense of the ontic structural realist view that properties depend on laws. It is unique in accepting both claims at the same time. I show that by doing away with the dogma of ontological priority between properties and laws, the two claims can co-exist in a cohesive view.

7.1 Ontological dependence

Before I get into the meat of this chapter – my proposed modifications to Dispositional Essentialism and Ontic Structural Realism, symmetric dependence and my hybrid view – I will say a bit about ontological dependence. Ontological dependence refers to metaphysical dependence – when one thing depends on another for its essence, identity or existence. Ontological dependence has popped up a lot in this thesis. Dispositional essentialists think that laws ontologically depend on properties. French proposes that properties depend on laws. However, I have not said much about what ontological dependence means. In this section, I will look at ways this term can be understood, hinting at the discussion of properties and laws to come.

Ontological dependence is a flexible term. It can mean a variety of things depending on context. Broadly, it refers to the dependence of one thing (or kind of things) on another thing (or kind of things). Here I take thing as a broad term for any kind of metaphysical entity, including objects, properties, and laws.

A lot of work has been done on breaking down ontological dependence into types, giving sets of conditions and specifications for different flavours. Perhaps best known is the difference between rigid and non-rigid existential dependence (Lowe, 2005). A thing rigidly depends on another if it could not exist without it. For instance, a set depends on its members. It would not be the same set without those exact members. Non-rigid existential dependence is more flexible. For instance, within an Aristotelian framework, a universal depends on its instances. However, it does not rigidly depend on any particular instance. Take the example of the universal of dog. If Fido and Rover are the

only dogs in existence, the universal depends on them. At the same time, the dependence is non-rigid because the universal could exist without Fido and Rover provided another dog (say Rex) instantiated it (ibid).

There are many kinds of ontological dependence in the literature. Sometimes the dependence refers to identity dependence, dependence for existence, or dependence for essence. They are given detailed analyses, with examples and counterexamples fleshing out the space of possible types of ontological dependence. However, I follow Barnes' (2018) lead in staying neutral on the definition of ontological dependence.

It is worth noting that ontological dependence should not be confused with grounding. Grounding is a relatively new notion in metaphysics. Grounding is asymmetric (two things cannot ground each other), irreflexive (a thing cannot ground itself) and transitive (if x depends on y, and y depends on z, x depends on z). It is also well-founded meaning that grounding chains must terminate in something fundamental. Because grounding is so popular, and these two terms get conflated, some philosophers assume that ontological dependence shares all these formal features. However, this is mistaken (Barnes, 2018). Formal features like asymmetry are not built into the definition of ontological dependence. They are built into the notion of grounding.

Grounding explanations run in reverse of ontological dependence explanations. Grounding tells us why something occurs. If A grounds B, A generates B according to the formal features we saw above. However ontological dependence simply tells us what depends on what. So, if we want to speak about this example in terms of ontological dependence, B ontologically depends on A. So, where the grounding goes from A to B, the ontological dependence goes from B to A. I avoid talk of grounding in this chapter. I take it that if B depends on A, there is a sense in which A metaphysically explains or gives rise to B. I say "metaphysically explains" as this terminology is looser than the grounding terminology. It does not presume the set of formal features that grounding does. This is especially important given that later in this chapter I will argue that ontological dependence (and hence metaphysical explanation) may be symmetric. There is no room for such a thing in the grounding literature.

In sum, grounding is a far more restrictive notion than ontological dependence (Tahko and Lowe, 2016; Barnes, 2018). We cannot simply assume that all ontological dependence relations will follow the asymmetric, transitive, irreflexive and well-founded

model the grounding theorists endorse. Doing so would beg the question, assuming a set of formal characteristics for ontological dependence. These formal characteristics are still up for debate, and indeed will be debated later in this chapter where I argue for the possibility and existence of alternative species of ontological dependence.

Ontological dependence is a flexible notion with a large catchment. Most commonly ontological dependence is explained in modal terms. To say that X ontologically depends on Y is to say that X could not exist without Y existing (Tahko and Lowe, 2016). However, the modal variety has been criticised for being too coarse-grained. There are examples where a thing cannot exist without another existing, but we would not say that there is an ontological dependence link between the two.

Famously, there is the issue of necessary existents. Many believe that certain entities necessarily exist, such as numbers or God. Thus, for any contingently existing thing, we could say that it could not exist without numbers or God. If God necessarily exists, my hat cannot exist without God. Yet it is missing the point of ontological dependence to say that my hat is ontologically dependent on God (ibid). Ontological dependence loses its explanatory value here. Another example of where the modal analysis of ontological dependence may go astray is in the example of children and their parents. We can say that a particular child could not exist without their parents. In one sense this is true: had the child's parents not existed the child would not have existed either. However, in another sense this is false. The child can exist without their parents. Once the child is born, the parents can die, and the child will not fall out of existence.

Given the problems with the modal account and, again, the fact that ontological dependence is a broad term, there are alternative accounts of ontological dependence. One kind of ontological dependence which will feature heavily in this chapter is identity dependence.

When I talk about identity dependence, I refer to identity in the sense of individuality rather than a relation of identity (Lowe, 2012; Tahko and Lowe, 2016). An example of the relation of identity is to say that Clark Kent is or "=" Superman. I am not interested in this relation here. Rather, I am interested in what makes a specific thing (object, property, law, etc.) the kind of thing it is i.e. what individuates it. So, for instance, take a birth or a death. What individuates that event among others like it is the person who was born or died. One thing is identity dependent on another if it depends on that other

thing for its individuation. In other words, if gets its identity at least partially from that thing. It is important to note that identity dependence is tied to dependence for existence. After all, it is not clear what it would be for a thing to exist without its identity – or the thing it gets its identity from – existing (Tahko and Lowe, 2016, section 4.2).

One controversy surrounding identity dependence is whether it can be symmetrical i.e. whether two or more things can depend on each other for their identity. This is especially controversial as it would seem to imply that two or more things could depend on each other for their existence. This issue is particularly relevant for the views looked at in this thesis – Dispositional Essentialism and Ontic Structural Realism.

Both Dispositional Essentialism and Ontic Structural Realism have been accused of requiring symmetric dependence. This is because dispositional or structural views identify entities like properties purely via their relations to further properties, so all entities in the structure depend on each other for their existence (Barker, 2013; Jaag, 2014; Lowe, 2012; Yates, 2018). Some philosophers see this as a vice of the views. Much rides on how we view symmetric dependence. I leave discussions of whether properties and laws symmetrically depend on each other for section 7.5, where I cover these issues in depth.

In sum: ontological dependence is a flexible term and can be fleshed out in a variety of ways. In her paper – Symmetric Dependence – Elizabeth Barnes (2018) remains relatively neutral on what is meant by ontological dependence. I follow her in thinking that we can remain somewhat neutral on the precise definition of ontological dependence. However, I take it that if one thing ontologically depends on the other, it will not be able to exist independently of that thing. So, I take dependence for existence as a requirement for or inevitable consequence of ontological dependence.

7.2 Dispositional Essentialism

Dispositional essentialists by and large have traditional ontologies. They take properties to be universals (Ellis, 2001; Mumford, 2004; Bird, 2007; Tugby 2015). Further, they do not argue for revisions to our concept of objects in the way ontic structural realists do. However, for our purposes I am concerned with their ontological commitments regarding

properties and laws. They typically take properties to be fundamental and laws derivative. As we saw in chapter 2, "properties" here refers to regular, instantiated, determinate properties. I depict the standard approach in figure 3.

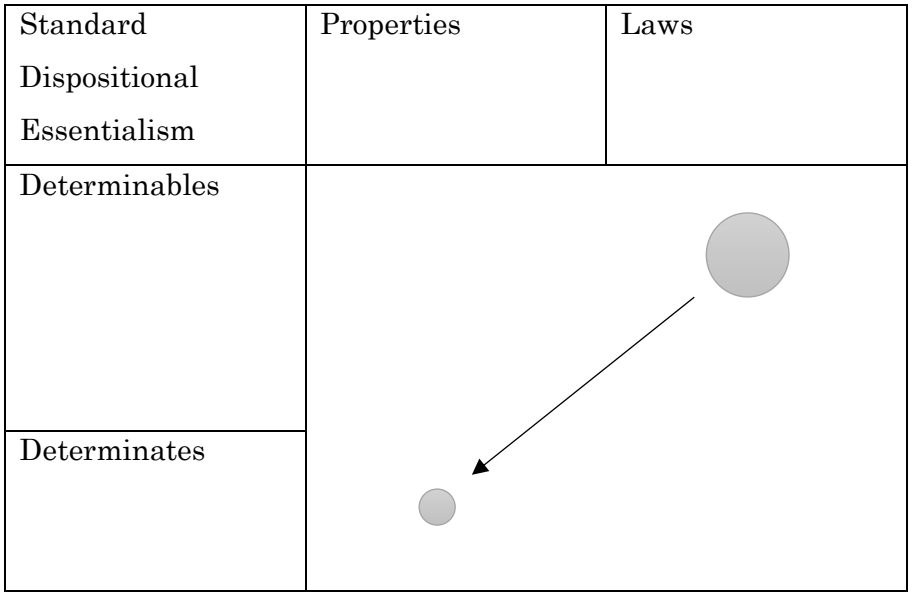


Figure 3. This figure depicts standard Dispositional Essentialism. The small circle represents determinates, in this case determinate properties. The big circle represents determinables, in this case determinable laws. The arrow represents ontological dependence. Within Standard Dispositional Essentialism, determinable laws are ontologically dependent on determinate properties.

In chapter 2 we saw that this picture is oversimplified. There is a huge problem with the idea that determinable laws ontologically depend on determinate properties. The issue stems from the fact that the modality of a determinate property at best can metaphysically explain, or give rise to, a determinate law i.e. a limiting case of the determinable law. However, it cannot give rise to the determinable law because this law covers both the behaviour of the particular determinate and all others, including determinates which may not even be instantiated. It seems odd to think particular instances of a general law metaphysically explain the general law. Or, in other words, it seems odd to think that the general law is ontologically dependent on the instance. Rather, it seems like we get the instances from the general law. The elegance and precision of laws like Coulomb's law cry out for explanation. The fact that all the determinate charges obey Coulomb's law cannot be left brute. This goes against the explanatory aims of Dispositional Essentialism.

In chapter 3 I argued that the problem can be solved via realism about determinable properties. This solution was inspired by Wilson's work (2012). She points out that we need both determinate properties and determinable properties in our ontology as they fulfil very different functions. We need determinables to give us the modal facts about the world. These explain the general laws we see. Determinates, on the other hand, act as 'existential witnesses' to determinables. They are instantiated properties. Without instantiated properties we would have a purely modal, or hypothetical, world without any concrete instantiated things. In light of these proposed modifications, my previous representation of Dispositional Essentialism in figure 3 no longer holds. I have represented the new modified version in figure 4.

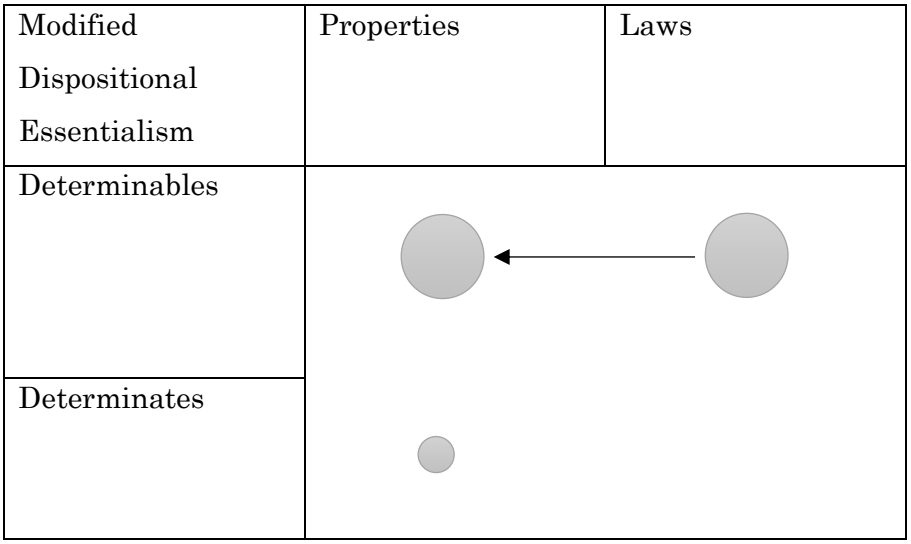


Figure 4 - depicts modified Dispositional Essentialism. Determinate properties cannot give rise determinable laws. Determinable properties are needed. The arrow represents the ontological dependence of determinable laws on determinable properties. I will look at the relationship between these categories and determinate properties in section 7.4.

Figure 4 changes two things relative to figure 3 (standard Dispositional Essentialism). The first thing it does is add determinable properties. This is because determinate properties cannot explain the existence of determinable laws. Dispositional Essentialism aims to explain all modality from the nature of properties. As such, it cannot leave the fact that all the determinates obey the same determinable law unexplained. This would run counter to the explanatory aims of Dispositional Essentialism. The determinable law must be accounted for. And, as we just saw, the only properties which can explain

the existence of these laws are determinable properties – the properties the laws are about.

The second thing it does is change the ontological dependence arrow. I remove the arrow representing the ontological dependence of determinable laws on determinate properties. I run the ontological dependence from determinable laws to determinable properties. Determinable laws ontologically depend on determinable properties. Another way of looking at this is that determinable properties give rise to determinable laws. Here by give rise to, I mean that they are the metaphysical explanation or cause of determinable laws. They are prior to determinable laws and are the reason we have these laws. The change of the ontological dependence arrow is needed for determinable properties to do the work they were posited to do. After all, if we could have metaphysically explained determinable laws via determinate properties we would not have posited the determinable properties to begin with.

I have one more change to make to the depiction of Dispositional Essentialism. The picture painted thus far is glaringly incomplete to me. Within Dispositional Essentialism, properties give rise to laws. This is because these properties are modal or dispositional. The laws encode those dispositions. The laws lay out the ways in which the property can manifest. Thus, we cannot have a dispositional property without that property giving rise to the corresponding law.

We cannot posit a dispositional property without generating a corresponding law. I have shown that determinate properties cannot generate determinable laws. We need determinable properties to do this. Yet, as dispositional properties, determinate properties will also give rise to laws. Dispositional properties are modal, they are law-generating. The laws determinate properties give rise to cannot be determinable laws, as these far outstretch the modality of the determinate properties. Rather, determinate properties will give rise to determinate laws. These laws are limiting cases of the determinable law, which cover the range of dispositions of the determinate property.

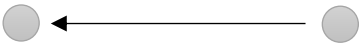
Complete Dispositional Essentialism	Properties	Laws
Determinables		
Determinates		

Figure 5. This figure illustrates my proposed changes to Dispositional Essentialism. Rather than determinable laws ontologically depending on determinate properties, they ontologically depend on determinable properties. For every dispositional property there will be a law of suitable scope. I will look at how the determinates and determinables relate further in section 7.4.

Before I move on, there are a couple things to note. The first concerns the status of determinates. I have been uncritically employing Wilson's framework here. That framework gives separate roles to determinables and determinates. Determinables give us modal facts about reality whereas determinates give us non-modal facts. On the one hand, I think that this gives us valuable insight into the nature of these categories. On the other hand, this can be taken with a pinch of salt as there is a sense in which all properties – determinates included – are modal within Dispositional Essentialism. I leave this topic for section 7.3 where I expand on how to understand this distinction.

The second thing to note is that determinates are not necessarily single-track. Recall that Bird thought that fundamental properties would have a simple-stimulus manifestation condition. Contra Bird, Barbara Vetter shows that determinate properties can be irreducibly complex (2015).

As we saw in chapter 3, Vetter differentiates between two different levels at which properties are divergent or multi-track. The first is the level we have been looking at of determinates and determinables. Take the example of charge. Charge is determinable in the sense that many determinate charges (all magnitudes of charge) fall under it.

Further, any charged object will have a specific charge. This is because if an object has a determinable it will have a determinate of that determinable.

At the other-level – the level of the individual determinates e.g. specific charges – Vetter says that these are irreducibly and fundamentally multi-track. This is because each charge will encode the possibilities to react in a myriad of ways to every other charged object they may encounter. Even the determinate law for that determinate charge will allow for a variety of manifestations depending on the situation the charge manifests in.

Multi-track does not equate to determinable. The fact that an individual charge (or any other determinate) is multi-track does not mean that it is determinable. This is because it has all the corresponding single-track dispositions at once. Vetter explains that "Having a determinable property entails having *one* of its determinates, to the exclusion of all others. Having the multi-track disposition electric charge, on the contrary, entails having *all* the corresponding single-track dispositions." (2015, p. 53) Dispositions are multi-track in a fundamental way that goes beyond being determinables. After all, determinables require one determinate instantiation to the exclusion of all others, whereas multi-track properties have all the single-track dispositions at once.

That said, determinate laws may seem more open than determinate properties. This is because the determinate laws may still contain variables. Take Coulomb's law (see the table below). This law determines the electrical force (F) by multiplying the charges of the objects (Q_1 and Q_2), dividing their sum by the square of the distance between them (r^2), and multiplying the result by Coulomb's constant (K). So, the electrical force is proportional to the charge of the objects and inversely proportional to the distance between them.

Coulomb's law	$F = K \frac{Q^1 Q^2}{r^2}$
Determinate CL	$F = K \frac{\mathbf{5}\, Q^2}{r^2}$
Solution to CL	$F = K \frac{\mathbf{5 \times 8}}{\mathbf{10^2}}$

Figure 6

A determinate charge has the disposition to a possible infinitude of potential manifestations. This is reflected in the determinate law. This is seen in Determinate CL (figure 6), where I substitute one of the charges for 5. The equation still has a myriad of

solutions according to what other charged object the determinate charge encounters and at what distance they are to each other (what value Q_2 and r assume). The determinate law, which encodes the dispositions of the determinate property, is flexible in the sense that it has other variables. However, it has these because the manifestation of the charge depends on its interplay with other charges in the world.

Vetter (2015) proposes a different sort of determinate of Coulomb's law. This is of the kind I called "Solution to CL" in the figure above. In this version all the variables are filled in so we can calculate the exact result. There is only one outcome. If a charge of magnitude 5 meets another charge of magnitude 8, and they are at a distance of 10 units, the force exerted will be a specific amount. I do not take these to be the determinate laws generated by the individual determinate properties. Rather, this solution to Coulomb's law – this kind of uber determinate law – encodes the dispositions of multiple determinate properties. In particular, it encodes the dispositions of multiple determinate properties in contact with each other and the distance between them. The determinate property, on its own, cannot generate or metaphysically explain this kind of law.

There are two things worth noting before moving on. First, I do not see this flexibility of determinate laws as problematic. This is because the flexibility is already built into the dispositional properties. It is because each determinate charge can manifest in so many ways that the determinate law is so flexible. The determinate property manifests differently according to what other determinates it comes in contact with. Second, not all determinate laws are so flexible. Take, for instance, Einstein's mass-energy equivalence: $E = mc^2$. According to this law, the quantity of energy (E) is equal to the quantity of mass (M) multiplied by the square of the speed of light (c^2). This law only has two variables – mass and energy. If you know the determinate magnitude of one of those variables you can calculate the other. There are no other variables left. On a side note, this does not mean that mass and energy will not appear in other laws with more variables, it just so happens that this aspect of their disposition is fixed. In sum: determinate properties can be irreducibly multi-track. When this occurs, the determinate law will not have a unique and single solution. It will contain other variables. The law will have as many possible solutions as the property has possible manifestations.

7.3 Ontic Structural Realism

Broadly, Ontic Structural Realism is the view that only structure exists. Interpreting this claim has proven problematic. In the previous chapter, I laid out Steven French's Ontic Structural Realism (2014). I favour his reading for two reasons. First, French may well be the most prominent and published ontic structural realist. If anyone is an authority on the view, he is. Second, he is one of the most metaphysically engaged ontic structural realists. He gives the most detailed picture of the metaphysical assumptions and implications of the view.

In the previous chapter we saw that the motivations for Ontic Structural Realism are complex. They often reference quantum mechanics as requiring a revolution in how we perceive objects. I will not rehash these arguments here. Rather, I focus on the underlying ontology as regards the question of how properties and laws relate.

According to French, Ontic Structural Realism (like Dispositional Essentialism) aims to account for modality. Dispositional essentialists take the properties of ordinary objects to give rise to laws. Ontic Structural Realism does the reverse. It takes laws and symmetries to be fundamental – the fundamental structure of the world – and properties to be derivative.

In French's view, Dispositional Essentialism fails to account for laws. Dispositional Essentialism aims to explain all modality on the basis of properties which are determinate. However, determinate properties cannot explain laws because laws are determinable. If we take the determinate properties (as opposed to the determinable laws) to be fundamental, the fact that they all obey the same general law remains unexplained. French follows Wilson (2014). He agrees with her view that we need both determinates and determinables in our ontology. As we saw, Wilson argued that we need the determinables (by which she means determinable properties) to explain modality and determinates tell us what determinables are actually instantiated in our world. French gives his own twist to these ideas.

French agrees that we need both determinables and determinates. According to him, we need determinable laws in order to give us the modal structure of reality, and determinate properties to give us the non-modal facts which differentiate our world from other worlds. So, the ingredients he uses to account for modality end up being the same

as standard Dispositional Essentialism: determinate properties and determinable laws. However, he inverts the direction of the explanation in Dispositional Essentialism. He relocates the modality "shifting it along the line of dependence from the properties to the laws and symmetries themselves." (2014, p. 264)

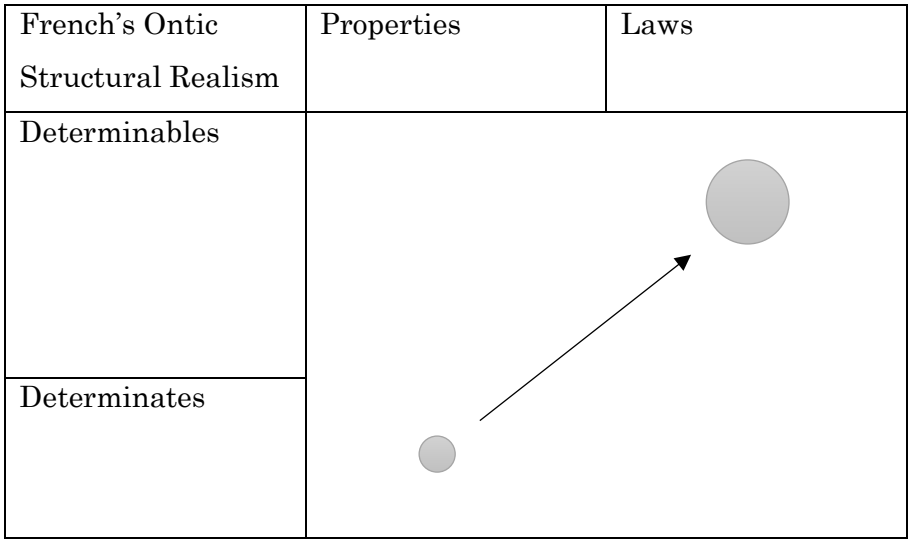


Figure 7 – depicts Ontic Structural Realism as an inversion of Dispositional Essentialism. It depicts French's shift of the dependence, so that determinate properties ontologically depend on determinable laws.

Figure 7 represents French's Ontic Structural Realism as a perfect inversion of Standard Dispositional Essentialism (figure 3). However, it must be noted that these two are not perfect mirror images of each other. Dispositional Essentialism takes determinate properties to be fundamental but not the determinable laws. As noted in the previous chapter, in French's work there is a tension between dependence and fundamentality here. On the one hand, properties are dependent on laws (2014, p. 264). On the other hand, we need both properties and laws in our fundamental ontology as they fulfil different explanatory needs (p. 290). We need the laws (determinables) to give us modality. However, we also need properties (determinates) to give us the non-modal facts about our world. Thus, we need both properties and laws in our fundamental base for that fundamental base to be sufficient to account for all aspects of our world. We could take French's view that properties are needed in the fundamental base to mean that properties are not ontologically dependent on laws. However, I do not read French this way. French explicitly claims that properties are "metaphysical by-product[s]" of laws (ibid, p. 285). This implies that properties ontologically depend on laws. They depend on laws for their existence.

I argued that Standard Dispositional Essentialism was incomplete. Determinable laws were relations between determinable properties and determinate properties instantiate determinate laws. So, it should not come as a surprise that I think that ordinary Ontic Structural Realism's ontology is incomplete for similar reasons.

The first modification I propose is to add determinable properties to the ontic structural realist ontology. Again, this goes back to the root of what properties and laws are. In ontologies that reject Categoricalism, properties are identified or individuated by the relations they enter into: the laws they follow. However, the laws are also individuated by the properties they relate. Laws of nature are, by definition, relations between properties. In fact, we can argue that this leap from laws to properties runs deeper than the reverse. Even within Categoricalism, laws are relations between properties (see chapter 2). Laws require the properties they relate to exist for their existence (this can and will be used to argue for symmetric dependence – see section 7.5).

Laws are relations between properties. Laws require properties if they are to be more than abstract relations. Properties differentiate laws from each other. But why do I insist that French's ontology have *determinable* properties? Determinable laws are relations between determinable properties. The law of gravitation is a relation between the determinable properties force, mass and distance. These properties are determinable as the law covers all possible solutions. The laws exist independently of which determinates (if any) exist in our world. The image I have in mind is depicted in figure 7.

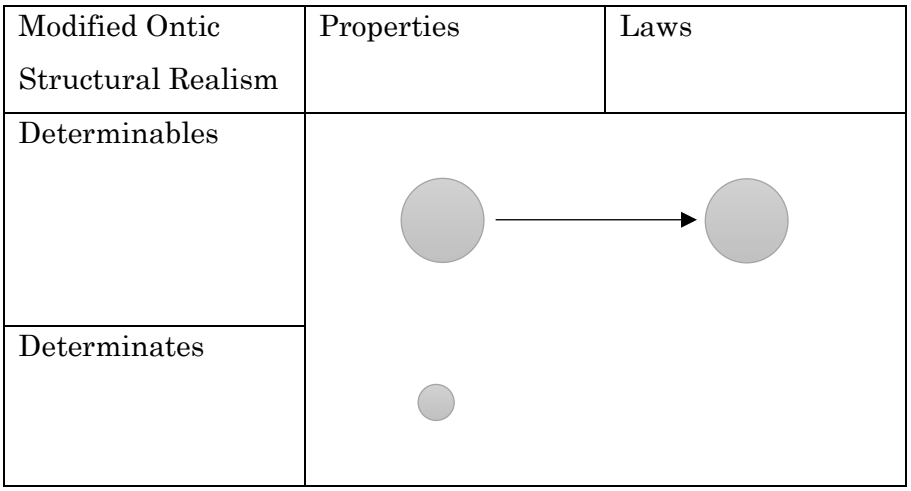


Figure 8. This figure represents modified Ontic Structural Realism. On this view determinable laws give rise to determinable properties. The ontological dependence is represented by the black arrow.

Figure 8 takes determinable laws to give rise to determinable properties. I have left their relation to determinate properties blank, as I look at the relation between determinates and determinables in section 7.4. I took the determinable laws to give rise to determinable properties because Ontic Structural Realism puts laws first. Within Ontic Structural Realism, laws give rise to properties. In other words, properties are ontologically dependent on laws. Naturally, the determinable laws give rise to the determinable properties (rather than the reverse). It would be off to say that the determinable properties do not exist, because then it is unclear what it is that the determinable laws relate or are about. However, the picture is still incomplete.

Recall that in 7.2 I argued that just as determinable properties require laws, determinate properties require determinate laws. The instantiation of a determinate property instantiates a determinate law. The determinate law encodes the full set of dispositions of the property in question. The point holds for Ontic Structural Realism too. Within Ontic Structural Realism properties have no transcendent existence. They are nodes in a relational structure. Determinable properties are nodes in the determinable structure – they are what determinable laws relate. Similarly, determinate properties will be nodes in the determinate structure; they will be the things determinate laws are about. Thus, for every determinate property there will be a determinate law. Given that we are talking about Ontic Structural Realism, that determinate law will come first and give rise to the determinate property, rather than the reverse.

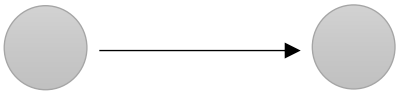
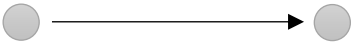
Complete Ontic Structural Realism	Properties	Laws
Determinables		
Determinates		

Figure 9 – depicts a more complete Ontic Structural Realism, where determinable properties ontologically depend on determinable laws and determinate properties ontologically depend on determinate laws. The only thing missing is the link between the determinable and determinate level, which I look at in section 7.4.

Figure 9 depicts my proposal for Ontic Structural Realism. Before, determinable laws explained determinate properties, or determinate properties were dependent on determinable laws. Now I have determinable laws giving rise to determinable properties. After all, determinable laws are relations between these properties. In addition, determinate properties depend on determinate laws. After all, these properties have no transcendent being above the relations they enter into. The ontological dependence arrow always goes from properties to laws. This is in keeping with French's requirement that properties depend on laws, or are metaphysical by-products of laws (rather than the reverse). Complete Ontic Structural Realism is quite similar to Complete Dispositional Essentialism. It has the same categories, but the dependence runs in reverse. Ontic Structural Realism remains a reverse-engineering of Dispositional Essentialism.

Before I advance, it is worth noting a few things. First, this picture remains incomplete still. I have said nothing about the relation between determinables and determinates, yet there is clearly a relation here. I address this issue in the next section.

Second, what I have said here may point to a different sort of link between properties and laws. If laws give rise to properties, properties depend on laws. But if laws are relations between properties, surely laws depend on properties too. This seems to suggest a kind of symmetric or mutual dependence. In this section I have been focused

on Ontic Structural Realism which is a laws first view. However, I take this point on board and even argue for symmetric dependence in section 7.5.

Finally, the link between properties and laws runs deep, deeper than what I have said here. Later in this chapter I will show that properties and laws depend on each other for their identity as well as existence. Within these views, properties are no more than nodes in a relational structure, they depend on their relations for their essence and existence. Further, laws are relations between properties. They are individuated by the properties they relate. This will give a new dimension and depth to the link between properties and laws. Further, it will help show why determinable properties and laws would come in pairs (and the same for determinate properties and laws).

7.4 What is the relationship between determinates and determinables?

Thus far I have argued that we need determinate properties and laws, and determinable properties and laws. However, I have not said anything about how these relate to each other. In this section I will look at important ways in which the determinates and determinables are related. However, I will also show why it is mistaken to think that one explains the other in the sense that one is fundamental and the other derivative. I argue that, despite the close relation between determinables and determinates, neither can be fully explained by the other. They are both independently needed in our fundamental base as they fulfil independent explanatory roles.

First, let's recap the most common features attributed to the determinate-determinable relationship as these inform much of the debate on which explains which. In 3.1 we saw that:

a) Determinates under the same determinable resemble each other in a way that they don't resemble determinates of different determinables. In the case of determinate properties, yellow resembles blue in a way that it cannot resemble circular or square; in the case of determinate laws, a determinate of Coulomb's law resembles another in a way it won't resemble a determinate of Newton's law of gravitation.
b) Determinates of the same determinable are mutually exclusive

c) If something has a determinable property it must have a determinate property. If something enacts a determinable law, it will enact a determinate law.
d) Determinables do not fix determinates
e) Determinates fix determinables (Johansson, 2000; Funkhouser, 2006; Wilson, 2012 with my own additions).

7.4.1 Overdetermination and the case against fundamental determinables

As we saw in 3.2, philosophers are often deflationary or eliminativist about determinable properties. This is partially due to a push to slim down their ontology: a minimal ontology is considered more parsimonious and desirable. Further, this move is motivated by apparently convincing arguments. I will look at these arguments in this subsection before arguing, in the next, that we do need determinables as well as determinates in our ontology.

One good argument for saying determinables are less robust than determinates, is that determinates appear to explain determinables, but not the reverse (Gillett and Rives, 2005). If an object has a determinable it must have a determinate (c). The determinable does not fix the determinate (d), in other words, the determinable does not give us any information about which determinate is instantiated. However, the determinate does fix the determinable (e). In other words, if we know what determinate an object has, we know what determinable it has. There is no room for wiggle.

There is a sense in which determinables look like collections of determinates, or abstractions of determinates. They do not seem to add much to the object that instantiates them given that the determinate suffices to explain the behaviour of the object, the evolution of the world and the determinables themselves.

Causal overdetermination can be invoked to argue that determinables are superfluous (Gillett and Rives, 2005). An event is causally overdetermined if there are multiple distinct and sufficient causes for its occurrence. This is such that any one of these causes is sufficient to explain the occurrence of the event. This kind of overdetermination is often frowned upon due to parsimony concerns. If we give multiple different sufficient causes for an event it can seem like we have not decided which really caused it. That said, overdetermination is not always vicious. Sometimes, there could be multiple

sufficient causes for something to happen such that it is truly overdetermined. Each case of overdetermination requires individual attention to figure out whether it is vicious or acceptable. In the case of determinates and determinables, determinable explanations are often seen as problematically overdetermined. Let's look at how overdetermination might be damning for determinables.

Stephen Yablo's (1992) example of Sophie the pigeon (see 3.2) has been invoked by other philosophers to argue that determinables are irrelevant to the causal story, and so should be removed. Say Sophie the pigeon was taught to peck at red objects. She is pecking at a red object. This could be explained by the fact that the object is red. It could also be explained by the fact that the object is scarlet or crimson. The determinate and determinable explanation seem interchangeable. The determinate and determinable explanations overdetermine Sophie's behaviour. Let's look at another iteration of the Sophie example which can be used to argue that it is the determinate explanation that does the work, not the determinable explanation.

Imagine that Sophie has only been trained to peck at crimson objects. The fact that the triangle is crimson determines that Sophie will peck on it. There is no need to explain her behaviour also by the fact that the triangle is red. But worse, explaining her pecking by the fact that the triangle is red leaves something out and is blatantly misleading. There are plenty of red objects she will not peck at e.g. scarlet or maroon objects. Here the determinate property is doing the work. Sophie the pigeon is not an isolated incident.

Any time we can give a determinable cause for an event, a determinate cause will also be available. However, the reverse is not true. The determinable cause often leaves something out. Determinate explanations are more fine-tuned, accounting for all scenarios. Determinable explanations, being general, will often miss nuance and provide an incomplete story. This is not just the case in the Sophie example. It is a problem for any explanation where a specific determinate or set of determinates could cause X but not others. For instance, say I have a drug that will numb the pain of a patient but if I give them too much it will kill them. If I want to explain the effect the drug had on a specific patient, the general properties of the drug will not do. The determinate quantity administered and the determinate weight of the subject, explain the effect the drug had. Thus, determinable explanations appear not only unnecessary but incomplete. As such, some feel they are best done away with (Gillett and Rives, 2005).

Armstrong (1997, chapter 16) provides an alternative argument for why determinables might depend on determinates. It is particularly interesting for our purposes because he speaks explicitly about the case of *determinate and determinable laws*. This as opposed to only talking about determinate and determinable properties, as much of the literature does. Each determinate property instantiates a determinate law. According to Armstrong, determinable laws are universals of the determinate laws. They cover all suitably related determinate laws. So far, so good. However, Armstrong views determinate laws as more fundamental than the determinable laws (whereas I don't for reasons I will give soon).

Armstrong is an Aristotelian about universals. He shows us how Aristotelianism can be a motivation for having determinables as secondary to determinates. By Aristotelianism about universals I mean the view that only immanent universals exist. In other words, Armstrong only believes in universals which are instantiated at some point in spacetime. Here Aristotelianism can be contrasted with the less popular Platonism. On the platonic view universals exist independently of their instantiations. The platonist would allow for a universal to exist without ever being instantiated, whereas that is nonsense for the Aristotelian.

In Armstrong's view, determinables are ontologically dependent on determinates. Determinables depend on determinates for their existence. This is because within the Aristotelian framework Armstrong uses, a universal cannot exist without its instance existing. In his words:

> "The existence of the determinable universal is entailed by, and so supervenes upon, the existence of each and every determinate universal falling under it. And, if the doctrine of the ontological free lunch is correct, the determinable is already 'in' the determinate, and so is no increase of being." (1997, p. 247)

As we have seen, many philosophers believe determinates are more fundamental than determinables. In their view, determinates explain determinables. This leads some to say that we do not even need both in our ontology. Worse, having both leads to overdetermination. In 7.4.2 I recap why we need both fundamental determinates and determinables in our ontology and in 7.4.3 I re-visit the overdetermination worry and argue that it is not a problem for my view.

7.4.2 Why we need fundamental determinates and fundamental determinables

I will now recap some reasons why determinables are not expendable and are needed in our fundamental base. I will also respond to Armstrong's argument that Aristotelianism about universals implies that determinables are dependent on their instances - determinates. I will respond first by saying that even within Aristotelianism there are different ways of interpreting the relationship between these determinates and determinables. There is a case for saying that the determinates also depend on the determinables. Second, Aristotelianism about universals is just one framework for viewing the issue. It is one option on the menu. Other options like Platonism could be used argue for the reverse i.e. that determinates are second to determinables.

We saw that there is a huge problem with the idea that determinates explain determinables within the views under consideration. Dispositional essentialists hoped to explain determinable laws via determinate properties. However, in chapter 3, we saw that determinate properties cannot account for the general claims of determinable laws. It is true that determinate properties will be modal within this view. However, they only encode the modality of determinate laws. A determinate property will only encode the dispositions that determinate has.

In chapter 3 I argued at length that the issue of accounting for functional laws within Dispositional Essentialism is fixed via fundamental determinables. Fundamental determinable properties are able to give rise to determinable laws. Qua Wilson (2012), I argued that we need both determinates and determinables in our ontology. The determinates tell us what is instantiated and the determinables give us the modality (more on this distinction soon).

Without fundamental determinable properties Dispositional Essentialism is at a loss to explain why all the determinate properties obey the same general law or equation. This clashes with the dispositional essentialist goal of accounting for all modality from properties. Thus, we need fundamental determinables. But what of Armstrong's claim that determinables are dependent on their instantiations?

Recall that Armstrong is an Aristotelian about universals. He only believes in instantiated universals. For a universal determinable property or law to exist, the determinate property or law must exist too. This leads him to view determinables as

dependent on determinates – their instances. While this argument is compelling, we are not committed to an Aristotelian framework. But, before I dive into that, it is worth noting that an Aristotelian framework is not committed to one-way ontological dependence of determinables/universals on determinates/instantiations.

While immanent universals will depend on their instances, we can argue that the reverse is also true. We can argue that instances also depend on the universals. Armstrong does not posit natural kinds and essences. However, most Aristotelians see instances as dependent on their kinds, or the universals of which they are instances. Indeed, universals were posited in part to explain why different properties resemble each other. For instance, there appears to be a commonality between different magnitudes of charge or different shades of red. For the universals advocate, these properties resemble each other exactly because they are instantiations of the same universal. Without the universal to unify them the resemblance would be accidental or brute. The universal plays an explanatory role, being responsible for the instantiations. As Barnes put it:

> "Immanent universals depend on their instances. Part of what it is to be a universal, on this picture, is to have instances. And individuals depend on their kinds—part of what it is to be those particular individuals is to instantiate those kinds. If being F is essential to x, then anything that fails to instantiate F isn't x. Part of what it is to be x is to be F. And so, plausibly, we can say that x depends on being F." (2018, p. 56)

Barnes points out that the instances may be equally dependent on the kinds to which they belong and of which they are manifestations. This looks like essence or identity dependence. And, if one thing depends on another for its identity there is a sense in which it depends on that thing for its existence. After all, it is not clear how a thing can exist without its identity or the thing from which it derives its identity. Barnes' suggestion is that, just as immanent universals depend on their instances, instances depend on their universals. If this is true, immanent universals are symmetrically dependent on their instantiations.

In this example, Barnes is talking about kinds. She is saying that it is not just the kind that depends on its instance, but the instance depends on the kind it is an instance of. However, this carries over to non-kind attributes, or to universals regardless of your

stance on kinds. Barnes said "individuals depend on their kinds—part of what it is to be those particular individuals is to instantiate those kinds." (ibid) Replace the words individuals and kinds for instantiated properties and universals and you have that: part of what it is to be those instantiated properties is to instantiate those universals. This is true for any property. If you believe in universals, all instantiated properties are instances of a universal. You cannot have an instance without the universal. A determinate property is a manifestation, or concrete materialisation, of that universal and acts accordingly.

The main downside to this view will be symmetric dependence. As we shall see in 7.5, dependence is often assumed to be linear, so that it cannot loop around in this way. However, I will argue, as Barnes does, that we should not let such assumptions bias us when confronted with examples which may be best explained via symmetric dependence. For me symmetric dependence is not a problem, so the Aristotelian avenue remains open. However, I will leave the more detailed discussion of dependence for the next section.

Say Aristotelianism could only be seen through Armstrong's lens, with determinables being less fundamental than determinates. The views under consideration – Dispositional Essentialism and Ontic Structural Realism – are not wedded to Aristotelianism. The main rival view of universals – Platonism – has been defended within Dispositional Essentialism (Tugby, 2013). Ontic structural realists rarely talk about what they mean by properties, so the topic is open.

Platonism about universals is the view that universals exist independently of their instantiations. So, for instance, we could have a world where a colour is never instantiated. The fact that the universal happens not to occur does not mean that it does not exist. Within this framework we do not have determinables being dependent on their instances. The determinables exist independently of their instances. Yet the arguments for why the instances may depend on the universal remain. It seems like the instance is what it is in virtue of the universal it instantiates. At the same time, I would argue that the determinates still have a part in our fundamental base. As we have seen, what determinates are instantiated is not explained by determinables. What properties and laws are instantiated in our world needs to be accounted for in our fundamental base. Without these the fundamental base is not able to metaphysically explain reality.

We need fundamental determinables, as well as determinates, in our fundamental base. Determinates alone are unable to account for modality. I have argued that Armstrong's argument, that immanent universals/determinables asymmetrically depend on their instances, is not damning for fundamental determinables. The immanent universal framework is not wedded to his one-way dependence. In other iterations, there is a case to be made that the dependence between universals and their instances is symmetric or mutual (more on symmetric dependence in section 7.5). Further, even if the immanent universal framework required this asymmetric dependence, we would not be wedded to it. There are many different theoretical frameworks in the properties literature. For friends of universals, there is Platonism. Platonism does not support the view that determinables depend on determinates. If anything, it implies the reverse. Further, universals are just one framework for understanding properties. Others, like trope theories, deserve their own exploration although such exploration is beyond the scope of this chapter. Now, let's revisit the criticism that if we have both determinates and determinables in our ontology, causation is overdetermined.

7.4.3 Overdetermination revisited

One of the biggest hurdles for a view like mine – which has fundamental determinates and determinables – is the threat of overdetermination. The issue is that determinates seem sufficient to explain any given event. If a charged object is attracted to another, we can explain the attraction via the determinate charges. We do not need to bring charge – the determinable – into the picture. But do these explanations really compete?

The causal exclusion argument in the philosophy of mind provides a fruitful debate on overdetermination. This argument aims to undermine all theories of mind aside from the identity theory – the view that mental states simply are physical states e.g. that there is no difference between certain neurons firing and pain. The causal exclusion argument generally targets non-reductive physicalism. Broadly, non-reductive physicalists think that mental states are connected to physical states but cannot be reduced to them. Mental states are often described as higher-level properties which could be realised by a myriad of physical states. For instance, pain might be realised by c-fibres firing in a human, d-fibres firing in an octopus and something else entirely in a Martian. Yet, all three may feel pain. Thus, mental states are often seen as multiply realisable by physical states.

If I touch a hot pan, and pull my hand away, there are two different explanations for my behaviour. One invokes the mental property, the pain I felt. The other invokes physical properties i.e. what neurons were firing in my brain at the time. The causal exclusion argument points out that the non-reductive physicalist is left with two distinct causes for my behaviour, and one must go. My behaviour is overdetermined. I cannot say that my neurons caused the behaviour without risking making my being in pain irrelevant to my recoil. If I say I recoiled because of pain, I risk dismissing the role my brain chemistry played in causing my behaviour. Daniel Stoljar (2008) aims to dispel this argument by focusing on the notion of distinct causes. In particular, he explores what is meant by "distinct". What counts as a distinct cause is key to the causal exclusion argument in the philosophy of mind as well as the overdetermination argument regarding determinates and determinables.

Stoljar points out that the person making the causal exclusion argument faces a dilemma. If the notion of distinctness is too strong then it will not apply to mental vs physical states (or, as we shall see, to determinates and determinables). If the notion of distinctness is too weak the kind of overdetermination described is rampant and therefore the non-reductive physicalist (and, as we shall see, the realist about determinables) need not worry about it.

Exclusion 1 is a form of the exclusion argument with a strong notion of distinctness. In particular, Stoljar goes for strong modal distinctness whereby "F is strongly modally distinct from G if and only if it is possible that F is instantiated and G is not *and* it is possible that G is instantiated and F is not." (p. 266) In other words, in this iteration, two things must be entirely modally independent of each other to be distinct. This kind of exclusion argument may succeed against the dualist - someone who believes the mental and physical to be entirely different. If they say that my brain state causes me to pull my arm away from the hot pan, and that my mental state also causes me to pull my arm away, the event is overdetermined in a strong way. However, this kind of overdetermination will be rare. In fact, using such a strong notion of distinct benefits the non-reductive physicalist as they do not claim that mental and physical properties are strongly modally distinct. As a result, they do not risk this kind of strong overdetermination.

Exclusion 1 will not hold for the non-reductive physicalist as they would not take it that mental states and their physical realisers can exist entirely independently of each other.

Even if pain can be multiply realised, it seems that the realisers cannot exist without the pain existing. The non-reductive physicalist may argue that my pain neurons cannot fire without being accompanied pain. More importantly for our purposes, determinates and determinables are clearly not strongly modally distinct. You cannot have a determinate without a determinable. So, determinates and determinables do not count as distinct causes here and would not be target to this kind of causal exclusion argument. If anything, determinates and determinables are better at dodging the problem. Pain might be inhibited by a painkiller, but a determinate cannot ever exist without the determinable being instantiated.

One might object that the notion of distinctness levelled in Exclusion 1 is too strong. We can reformulate the causal exclusion argument with a weaker definition of distinct. Let's call Exclusion 2 a version of the causal exclusion argument which takes distinct to mean numerically distinct. In other words, everything which is not numerically identical, or identical in every way, is distinct. This argument will be very different from Exclusion 1. Exclusion 2 is better targeted at the non-reductive physicalist, attempting to catch them invoking competing causes.

Stoljar points out that this form of the argument has many exceptions. If no numerically distinct things may be causes, we risk eliminating many plausible causes of things. For instance, my having 70 000 hairs on my head seems to justify my not being bald, but so does my having 80 000 hairs. These are numerically distinct, and don't really seem to compete. More importantly, Stoljar gives a very, very, pertinent example of an exception to this argument. He mentions Sophie, the pigeon. She is pecking at something crimson. We could also say that she is pecking at something red. Yet these two are numerically distinct so they cannot both be causes for the pecking. "But then, by the exclusion principle that invokes numerical distinctness, being red is not relevant" (p. 273) This is very bizarre. If Sophie is trained to peck at all red things, can the redness of the thing she is pecking at really be deemed "not relevant". Even more pertinently, Stoljar explicitly says that Yablo's pigeon is "no counterexample" to Exclusion 1 (p. 273). It doesn't fall under Exclusion 1 at all. So, whether determinates or determinables count as competing causes, and run afoul of the causal exclusion argument, is completely down to what definition of distinct (causes) we use.

Determinates and determinables cannot be said to be distinct causes using a strong notion of distinct like strong modal distinctness. They are modally linked. We cannot

have the determinate without the determinable. And, in many metaphysical frameworks, we cannot have the determinable without the determinate. They are so joined that (as we saw in chapter 3) Shoemaker argues that the powers of the determinable are a subset of the powers of the determinate, so that these two are never in causal competition.

I do not see determinates and determinables as being in causal competition. Their relationship is too intimate for them to be pulled apart as separate causes with competing powers. Stoljar does a good job at showing that much talk of competing causes is done in the absence of a clear understanding of what makes one cause distinct from another. As a result, we can find ourselves slipping between weak and strong notions of distinct, or between Exclusion 1 and Exclusion 2, arguing cross-purposes. Yet, as Stoljar puts it, "It is as if someone has made an argument about riverbanks and suggested it applied to piggybanks […] premises about strong modal distinction don't give you conclusions about numerical distinctness." (p. 273)

The challenge to those who say determinates and determinables provide distinct and competing causes is to define distinct. If Stoljar is right they risk requiring such a weak notion of distinct that counterexamples are abundant and overdetermination pops up all over the place.

7.4.4 Loose ends

In this section I will shed light on some lingering issues for the account of determinate and determinable properties and laws. The first issue has to do with the fact that some of these seem like ontological free lunches or can be deduced from others. The second pertains to Wilson's claim that determinates give us the non-modal information about reality whereas the determinables give us the modal information. This allows me to move onto to the second half of the chapter where I talk about symmetric dependence and the many ways properties and laws are entwined.

The first issue that springs to mind with my account is that some of the four categories – determinate properties, determinate laws, determinable properties, determinable laws – might seem to be ontological free lunches. I say this because having information about some may allow us to deduce the others. For instance:

- If I know the determinable property, determinable law and what determinate property is instantiated, I can deduce the determinate law.

- If I know the determinable property, determinable law and what determinate law is instantiated, I can deduce the determinate property.

This might lead us to think that the determinate property or law is less fundamental or warrants less of a metaphysical commitment. It might seem like an ontological "free lunch". However, things are not so simple.

- If I know all the determinate properties, I can know the determinable property
- If I know all (or perhaps even many) of the determinate laws, I can infer the determinable law

It goes both ways. It is not just that we can infer determinate properties/laws but we can also infer determinable properties/laws given the right circumstances. Of course, there are some disanalogies here. For instance, we can infer the determinable from the set of all determinates alone. However, to infer a determinate law we need information from both levels i.e. we need to know the determinable law in addition to the determinate property.

I have argued at length in this thesis that we need both determinates and determinables in our fundamental base. I will not resolve how exactly determinate properties, determinate laws, determinable properties, and determinable laws relate to each other. However, I hope to have shed light on the relationship between them. At the same time, I hope to have shown that it is *not* a relationship of ontological priority. Determinates and determinables share a close relation whereby determinates instantiate limiting conditions of determinables. Determinates must behave accordingly. Their close relation is seen by the examples of how we can, at times, deduce one from the other. However, we cannot fully explain determinates in terms of determinables or vice versa.

As we have seen, attempts to do away with determinates or determinables fail. They leave something unaccounted for. We need fundamental determinates to act as 'existential witnesses' to our universe. Without determinates there is nothing to differentiate our world from other worlds with the same functional laws. We need fundamental determinables to account for modality. Hence my saying that the relation

between determinates and determinables is *not* one of ontological priority. But what about the relationship between the properties and laws?

As we have seen, those of a dispositionalist leaning take properties to be primary and laws to be secondary. Those of an ontic structural realist leaning will do the reverse. I will not advocate for either of these as I will be arguing for an alternative position: that properties and laws mutually depend on each other for their identity and existence.

The other issue that needs addressing is Wilson's (2012) claim that within power views of properties, determinables provide modal facts and determinates provide non-modal facts or 'existential witnesses'. French (2014) echoes this view in the context of his Ontic Structural Realism. So, this view spans both the property debate and the structuralist debate, and I use it in constructing my hybrid view. However, some nuance and due diligence is needed here. While the idea that determinables give modal facts and determinates give non-modal facts gets at some truth, it risks oversimplifying matters. Let me clarify.

We opposed determinates and determinables based on modality. Determinates are non-modal and determinables are modal. While the second part may be true, the first is questionable. Can we really say that determinates are non-modal within a dispositionalist framework? I would argue that we cannot. After all, each determinate property will get its identity and essence purely from its dispositions i.e. its potential interactions with other properties. Modality seems written into its essence – modality is its nature. And, as Vetter points out, that modality may be unbounded given that maximally determinate properties are often multi-track (2015). A single charge can manifest in endless ways. It will manifest differently according to every possible set of other determinate charges that cross its path.

On the other hand, there is an important insight in the view that determinables are modal and determinates provide non-modal facts. Determinables are pure potentiality. A set of determinables gives us no information about what is actually instantiated in our world. We cannot differentiate our world from other possible worlds with the same properties and laws based on determinables. Additionally, determinates do tell us what is instantiated in our world. They give specific initial conditions from which to explain the causal sequences we witness. They differentiate our world from other worlds.

The take-home message here should not be that determinates are non-modal, but that they provide non-modal facts or information. So, I take non-modal here to mean non-modal in a qualified way. I do not mean that they are not modal in the sense that they are not dispositional. We cannot have entirely non-modal properties within the kind of dispositionalist/structuralist frameworks I have been looking at. However, we can have non-modal facts i.e. we can know which determinates are actually instantiated. So, the non-modality of determinates refers to this - to their providing these non-modal facts.

With these loose ends behind me, I can finally proceed to my discussion of symmetric dependence. In the next section I will argue that symmetric dependence is a live option and, further, that properties and laws symmetrically depend on each other.

7.5 Properties and laws: a case for symmetric dependence

Earlier I looked at the ontologies of Dispositional Essentialism and Ontic Structural Realism. In their standard form both explain modality via two categories: determinate properties and determinable laws. However, they differ on which takes ontological priority. I argued that both sides had oversimplified ontologies. First, I argued that determinable laws require determinable properties. Laws are relations between properties. Determinable laws are relations between determinable, not determinate, properties. Determinate properties are too narrow to explain the determinable laws or to be what those laws are about. Second, I argued that if determinate properties exist, determinate laws exist. This seems almost trivial within a dispositionalist/structuralist framework. In this section, I dive further into the reason why properties seem to require laws, and vice versa. I look at how properties and laws depend on each other for their very identity and existence.

Is the dispositional essentialist right to say that the modality runs from properties to laws? Is French right to say that the modality runs from laws to properties? I will argue that both are wrong. Properties and laws are entwined. Neither can be prior to the other. In this section, I will look at different kinds of dependence. I start by looking at dependence for explanation in epistemology. I lay out three ways chains of reasoning can be founded: foundationalism (they end in a foundational reason), coherentism (they terminate in mutually supporting reasons) and infinitism (they go on forever). I then

show the parallel in metaphysics where chains of ontological dependence can either bottom out (foundationalism), interdepend or go on forever (infinitism). I argue that the dependence between properties and laws is of the second kind – they depend on each other for their identity and existence. The connection between the two is such that we cannot establish links of ontological priority between them.

7.5.1 Dependence in Epistemology

The Agrippan Trilemma is one of the oldest problems in epistemology. According to this argument, when asked to justify any proposition we must choose between three options:

> A. We can rest our argument on a proposition that is not justified on the basis of any other proposition. This position is problematic because it bases knowledge on a dogmatic assumption, wh ich goes against the intuition that all knowledge-claims are, in principle, justifiable.
>
> B. We can argue in a circle, so that we give the same criterion as before or use our conclusions to justify our premises. This option is problematic because circular reasoning is generally considered fallacious.
>
> C. We can give an infinite chain of reasons since every reason given "needs another such source [reason], which needs another, and so on *ad infinitum*, so that at no point do we establish anything." (Empiricus, 2000, p. 166)

Since each of these options is problematic, ancient sceptics like Sextus Empiricus used Agrippa's Trilemma to argue for the suspension of judgement (for we have no way to determine the truth or falsity of propositions without attempting to justify them in one of the aforementioned ways). However, epistemologists determined to salvage knowledge have proposed three "solutions" to the Agrippan Trilemma: Epistemic Foundationalism, Epistemic Coherentism and Epistemic Infinitism.

The first possible solution to the Agrippan Trilemma is to bite the first bullet and endorse Epistemic Foundationalism. " According to the epistemic foundationalist, the human belief-structure is hierarchically arranged and well-founded: chains of beliefs ordered by a linear justification relation terminate in basic, non-inferentially justified beliefs" (Bliss, 2011, p. 61). Historically this has been the most popular option with philosophers arguing that certain propositions do not need propositional justification to

be justified. Ernest Sosa (1980) proposes that there are levels of reasons. If we want to know why a proposition is justified, we move down from one level to another until we find the bottom level of indubitable propositions. Some philosophers favour isolating a kind of proposition which functions as our indubitable foundation e.g. propositions about our direct sensory experience. Most famously, Descartes attempted to find one indubitable proposition which he could not doubt - "I think therefore I am". However, the way in which he went about building his system of knowledge is quite controversial.

While Epistemic Foundationalism may be the most popular horn of the Agrippan Trilemma it is receiving increasing criticism. Critics claim that it either leads to dogmatism or falls into Epistemic Infinitism. At some point we reach the hopeful foundational reason or proposition. This will either be justified or will not be justified. If it is justified then we have not found a foundational belief. If it is not justified then, well, it is not justified. Further, given that there is no consensus on which beliefs don't require further justification it seems arbitrary which ones we pick. "Pick your favourite property, F, that marks off basic propositions from non-basic ones." (Klein, 2007, p. 4) If the epistemic foundationalist wishes to avoid the charge of being arbitrary he must attempt to justify his belief that *b* is justified because it has F which lands him in another regress. "Call this the meta-regress problem - any time you propose a regress-ender, you do so on the basis of an argument, which needs due diligence. And that puts us back on the road to regress." (Aikin, 2009, p. 56) In light of this there has been a revival of alternative positions, namely Epistemic Coherentism and Epistemic Infinitism.

The second solution to Agrippa's Trilemma is Epistemic Coherentism where justification depends on coherence with a particular set of beliefs, for instance, all of the agent's other beliefs about the matter. This view is often criticised for involving circular reasoning, which is considered fallacious. However, BonJour argued that the charge of circularity was misleading since it relies on a linear conception of justification (where justification is transferred from one belief to another via inference in a linear sequence). So, in order to escape the circularity charge, he proposes a non-linear "holistic" view of justification where "there is no ultimate relation of epistemic priority" among the beliefs in a set (BonJour, 1976, p. 287). On this view, "The component beliefs are so related that each can be justified in terms of the others; the direction in which the justifying argument actually moves depends on which belief is under scrutiny" (Ibid). Whether this appeal to non-linear and non-hierarchical justification does away with the circularity

concern is up for debate, however a thorough consideration of Coherentism is beyond the scope of this chapter.[14]

Finally, we have Epistemic Infinitism. Like epistemic foundationalists, epistemic infinitists view chains of reasoning as *hierarchical and linear* but, unlike epistemological foundationalists, they allow those chains to *extend infinitely*. This has been criticised for obvious reasons. First, we are finite beings who cannot possibly go through the infinite series of reasons needed to justify a proposition. Second, it is difficult to see how a proposition can obtain justification from an infinite chain of reasoning. However, Epistemic Infinitism has become more sophisticated since Agrippa's time.

Peter Klein (2007) forwards a version of Epistemic Infinitism which he believes avoids the traditional criticisms of this view. Inspired by Wittgenstein, he argued that, in order to justify our claims, we need only provide as many reasons as the context demands. If someone asks me how I know there was an earthquake in Nepal, my answer - "because I saw it on the news" - should satisfy them. I do not need to demonstrate, say, that the earth exists in order to prove my point. "The existence of the earth is rather a part of the whole picture which forms the starting-point of belief for me" (Wittgenstein, 1979, p. 28e). Jeanne Peijnenburgh and David Atkinson (2013) defend yet another sophisticated version of Epistemic Infinitism. They are inspired by the Bayesian Theory of Confirmation, where the more reasons we give for our claim the closer we get to the probability of it being true. Their view allows justification to emerge from the chain of reasoning itself, getting stronger as the number of reasons increases (Ibid, p. 559), as opposed to being transferred from one initial proposition onwards.

7.5.2 Dependence in Metaphysics

In the previous section we looked at three ways chains of reasoning can be founded: Epistemic Foundationalism, Epistemic Coherentism and Epistemic Infinitism. We saw that philosophers tend to prefer Epistemic Foundationalism – the view that chains of reasoning must end somewhere. However, problems have surfaced with this view leading to increasingly sophisticated versions of Epistemic Coherentism and Epistemic

[14] These thorns of the Agrippan Trilemma are not necessarily mutually exclusive. Haack proposed a hybrid between Epistemic Foundationalism and Coherentism where there is a web of foundational beliefs we rely on (1993).

infinitism. Recently metaphysicians have been drawing a strong metaphysical parallel with the Agrippan Trilemma. The formal structure of chains of ontological dependence is increasingly debated. Philosophers like Ricki Bliss (2011), Matteo Morganti (2014), Jonathan Schaffer (2010) and Naomi Thompson (2016) have pointed out that there are three options here too: Metaphysical Foundationalism, Metaphysical Interdependence or Metaphysical Infinitism.

Metaphysical Foundationalism is the view that chains of ontological dependence terminate with something fundamental which does not ontologically depend on anything else. It is "orthodoxy in contemporary metaphysics" going "largely unchallenged" (Bliss, 2011, p. 71) for it fits with the intuitive view of the universe as hierarchically structured. Or, in metaphysical jargon, the view that chains of ontological dependence are *partially ordered* and *well-founded*. By well-founded we mean that these chains terminate. By partially ordered we mean that these chains are asymmetric (two things cannot depend on each other), irreflexive (a thing cannot depend on itself) and transitive (if x depends on y, and y depends on z, x depends on z).

Metaphysical Infinitism allows for chains of ontological dependence to go on infinitely. So, nothing is fundamental. This position allows for the foundationalist view that ontological dependence is asymmetric, transitive and irreflexive, however it does not agree with the idea that it must terminate (Bliss, 2011, p. 17). While I will not be concerned with this position here, it is worth noting that it is growing in sophistication and popularity. This is largely because of the recent interest and argumentation for the possibility of gunk (infinitely divisible substance).

Metaphysical Interdependence entails a holistic view of reality where entities are symmetrically dependent. Entities are able to ontologically depend on each other. Historically, this has been the least popular solution to the trilemma. "Metaphysical coherentism [interdependence] offends the sensibility in a way that metaphysical Infinitism does not" (Bliss, 2013, p. 246). It requires us to question the idea that reality is partially ordered i.e. that chains of ontological dependence are asymmetric, transitive and irreflexive. Further, the idea that entities ontologically depend on each other is so odd that it can seem unintelligible. Yet there are good scientific and philosophical reasons for this option.

We have already covered the scientific motivations for metaphysical holism in earlier chapters. To recap, the idea that reality is built out of discrete and discernible individual objects fails. On further scrutiny quantum objects, particularly electrons, have been shown to be utterly indiscernible. They share all the same properties – mass, charge and size. Further, they cannot be spatiotemporally differentiated because they do not have well defined spatio-temporal trajectories. At most they can be quantified – we can say how many electrons are in a particular system. This squeezes traditional views, where reality is composed of a bottom level of atomistic entities, out of the picture.

Quantum entanglement is responsible for increasing numbers of philosophers of science turning to the idea that reality is non-separable and holistic (Esfeld, 2009; Healey, 1991; Teller, 1986; Schaffer, 2010). As we saw, quantum objects are often entangled. They share certain properties which their parts lack.[15] The classic example is that of two electrons with a joint spin of zero. They do not have individual spins. Rather, their individual spins are fixed at the exact moment we measure them at which point the entanglement breaks. If the first has positive spin, the second is instantly determined to have negative spin (or vice versa). Importantly, this is just the toy example. Entanglement is widespread, challenging pluralist foundationalist intuitions and breathing new life into the debate on metaphysical holism. I set aside the scientific motivations for metaphysical holism. These cannot be settled here. However, they are worth bearing in mind before dismissing holism out of hand.

7.5.3 Symmetric Dependence

Symmetric dependence is a case of Metaphysical Interdependence. If two entities are symmetrically or mutually dependent, neither can exist without the other. However, symmetric dependence is different from holism. Holism implies that all of reality is intertwined. I will not argue for this. My aim is humbler. I argue that at least in the case of properties and laws we have good reason to think that there is symmetric dependence.

While Metaphysical Interdependence is unpopular, and few consider it to be an option, increasing numbers of philosophers have been flocking to this view. We have already

[15] Of course, there are many interpretations of quantum mechanics and this may not hold of some of the more exotic ones. However, quantum entanglement is widely accepted in the literature and is accepted as a real phenomenon regardless of one's interpretation of quantum mechanics.

seen that there is increasing pressure from current physics to discard our ordinary foundationalist intuitions about dependence and consider holistic alternatives. However, there is also growing advocacy for symmetric dependence within metaphysics. Barnes (2018) and Naomi Thompson (2016) both argue that we should drop the expectation that ontological dependence is asymmetric. That is not to say that all ontological dependence is symmetric. Rather, ontological dependence could be asymmetric in some cases and symmetric in others. (A)symmetry does not enter the definition of ontological dependence.

When people talk about ontological dependence, they often assume that it is asymmetric. However, Barnes and Thompson argue that this assumption is unwarranted (2018; 2016). The asymmetry assumption is partially due to a fear of circular reasoning. The issue is that, if A explains B and B is then used to explain A, there is a sense in which no new information is gained. Lowe (2012) argues against the power view of properties on the basis that properties get their identity from their relations to further properties. He takes this kind of symmetric dependence to indicate circular explanation which is not acceptable. The flip side is that many philosophers do not see this circularity as vicious at all. As we have seen, dispositional essentialists can argue that the modal nature of properties justifies them being identified in relation to each other. In addition, the circularity is not problematic because each property has a unique profile – a unique set of relations to further properties or a unique place in the property structure.

More broadly, using the unpopularity of circular explanations in epistemology to argue against symmetric dependence in metaphysics is often deemed fallacious. One issue is that circular explanations are sometimes satisfactory. There are various sorts of examples for this. First, Thompson gives Achinstein's examples of identity explanations "such as explaining the fact that the pH value of a solution is changing by appeal to the fact that the concentrations of hydrogen ions in that solution is changing, or explaining the fact that ice is water by appeal to the fact that ice is composed of H_2O molecules." (2016, p. 45) Another kind of example would be where ordinary beliefs support each other. For instance, I may believe that today is Wednesday because I believe that yesterday was Tuesday and Wednesday comes after Tuesday. If someone asks: "why do you think today is Wednesday?" and I say: "because yesterday was Tuesday", it seems like I have given them as good an explanation as any.

Another issue is that the epistemological debate on circularity does not necessarily map onto the metaphysical one. We cannot simply import conclusions on circularity in epistemology to metaphysics. One can accept one horn of the Agrippan Trilemma in epistemology but a different one in metaphysics. For instance, I can be sure that explanations go on forever (Epistemic Infinitism), and that humans have no foundational beliefs, but be persuaded that chains of ontological dependence must bottom out (Metaphysical Foundationalism). This is because I can have metaphysical reason to believe that reality is hierarchically structured without believing that humans have access to foundational reasons. Ultimately, we will have to weigh the evidence for metaphysical interdependence or symmetric dependence before dismissing it. And, as we shall see, Barnes argues that there are many examples from metaphysical debates where metaphysical interdependence appears to be the most plausible explanation for what is going on.

A final reason why philosophers tend to assume that ontological dependence is asymmetric is because ontological dependence is often spoken of in the context of fundamentality, grounding, or in virtue of relations (Barnes, 2018, pp. 54-5). These notions arguably have asymmetry built into them. However, we saw that ontological dependence is the broader notion which incorporates any kind of dependence of one entity, or kind of entities, on another (or others). If one thing ontologically depends on another, it cannot exist independently of that thing. However, that does not tell us whether the dependence must be asymmetric at all. On the contrary, Barnes uses many examples from metaphysics to argue that we have reason to think that ontological dependence is non-symmetric. This is because there are many cases scattered across metaphysics where symmetric dependence may well be the best way to explain the phenomenon.

- We looked at Barnes' first example of symmetric dependence above. This is the relationship between immanent universals and their instantiations. Advocates of immanent universals take only universals with instantiations to exist. As a result, the existence of the universal appears to depend on the existence of its instantiation. At the same time, the instances depend on their universals. The universal informs what kind of thing the instance is. The instance is what it is in virtue of being an instance of the universal. While the dependence of the universal on the instance is a bit different from the dependence of the instance on the universal, in both cases it seems that we cannot have the one without the

other. The existence of the immanent universal requires that of the instance and vice versa.

- Another example comes from trope theory. Trope theorists reject universals, seeing properties as particulars. If these resemble each other that resemblance is brute and not the result of them partaking in the same universal. A big problem for trope theory is the idea that there could be a free-floating mass. Yet we cannot imagine a free-floating mass without shape and size. "Part of what it is to have mass is to have shape and to have size, for example. And part of what it is to have shape is to have mass and to have size. And so on. These properties are all interdependent." (pp. 58/9)
- Finally, mathematical ontology – particularly non-eliminative structuralism – provides another case of possible symmetric dependence. On this view numbers are "nodes or positions in a mathematical structure. Non-eliminativist structuralists often say that each node of the structure depends on all the other nodes—and perhaps even on the *structure itself* as well." (2018, p. 60) In this scenario the nodes (numbers) end up being dependent on the relations they bear to each other. At the same time, the relations are relations between numbers, so the relations are dependent on the nodes for their existence. This example is particularly interesting for our purposes. As we shall see, this kind of number differentiation shares striking similarities with how properties are differentiated within Dispositional Essentialism.

In sum, Barnes gives a bunch of examples, across an array of topics in metaphysics, where dependence appears to be symmetric. She does not argue that any of these prove her view that dependence is non-symmetric. We may disagree with one or more of these examples. However, she argues that their "dialectical force when taken together is… greater than the sum of their parts." (2018, p. 61) Barnes concludes that, against this array of examples, we simply cannot assume that ontological dependence is asymmetric. We have good reason to leave the possibility of symmetric dependence open.

I agree with Barnes' conclusions. I will not debate her examples here. Instead, my focus will be on another example: properties and laws within dispositionalism/structuralism. I argue that symmetric dependence is the best framework for understanding the relationship between properties and laws in these theories. Thus, if you are a dispositionalist or structuralist you ought to endorse a symmetric dependence view.

7.5.4 The hybrid view – why properties and laws ought to be seen and symmetrically dependent in structuralism and dispositionalism

In this section I return to my prime concern: accounting for modality. As we saw, Dispositional Essentialism takes properties to be fundamental and laws to be dependent. Ontic Structural Realism does the reverse. It takes laws to be fundamental and properties to be dependent. Here I argue for a hybrid view, where properties and laws are both fundamental. Rather than one depending on the other, they symmetrically depend on each other. I will start by looking at the relationship between properties and laws in Dispositional Essentialism. This allows me to show that there is motivation for symmetric dependence within this view. After, I turn my attention to Ontic Structural Realism. I show that structuralism shares important similarities with dispositionalism. In both views properties and laws rely on each other for their identity and existence. Thus, there is motivation from structuralism for my symmetric dependence view.

This view is a hybrid between Dispositional Essentialism and Ontic Structural Realism's views on modality. Dispositional Essentialism took the ontological dependence arrow to go from laws to the properties on which they depend. Ontic Structural Realism took the ontological dependence arrow to go from properties to the laws on which they depend. I reject both in the sense that I reject the ontological priority of one over the other. However, I do not reject the arguments for fundamental properties or fundamental laws. I take on board the points of both views, arguing that we need both properties and laws in our fundamental base. In my view, the necessity of the existence of properties for the existence of laws (and vice versa) is too strong to choose one as fundamental over the other. Properties and laws are interconnected and interdependent.

7.5.4.1 Dispositional Essentialism

According to Dispositional Essentialism properties give rise to laws. This claim is motivated by three things. First, it is motivated by the intuition shared by most metaphysicians that properties are fundamental. They are ways the world is, they cannot be explained away as dependent on laws or anything else. Second, the rejection of Categoricalism and the view that properties are modal (explored at length in chapter 2). Third, laws are relations between properties. This seems to require properties to be fundamental, and laws to be derivative. The laws are ontologically dependent on the properties because relations ontologically depend on the things they relate. Relations

depend on their relata for their existence. However, the apparent simplicity of this view disappears on further inspection.

By putting properties first, and having them account for modality, the status of laws becomes unclear. Some argue that there is no role for laws as properties do all the work (Mumford, 2004). I will not be concerned with this view. The problems I highlight for the standard view are, if anything, more problematic for this view. The real issue concerns the fact that properties appear to be constituted by the relations they are supposed to give rise to or ground. This problem has been increasingly appreciated in the literature (Barker, 2013; Jaag, 2014; Tugby, 2015). This calls the very coherence of traditional Dispositional Essentialism into question. As we shall see, the idea that a thing is constituted by that which it grounds makes no sense.

We saw that Barnes uses non-eliminative structuralism in mathematics as an example of possible symmetric dependence. For these structuralists numbers are seen as nodes in a graph. They get their identity via their relations to all other numbers. So, for instance, the number 2 is what it is because it is half of four, double 1, etc. Thompson argues, if this theory is true, we likely have symmetric dependence between the nodes (the numbers) and the relations between them. After all, the nodes get their essence from the relations. The nodes have no essence or existence beyond what relations they enter. At the same time, the relations are nothing more than connections between nodes. We need nodes to have the relations between them. While I won't argue for any particular conception of numbers here, this very closely mirrors what happens in Dispositional Essentialism.

Bird (2007) relies on graphs to illustrate the fundamental nature of properties within Dispositional Essentialism. He uses graphs to illustrate how properties can have separate essences and be individuated using only their relations to further properties. Where the mathematical structuralist takes the nodes in a graph to be numbers, Bird takes the nodes to be properties. He argues that these properties get their identity purely from their relations to further nodes. The relations are depicted as the arcs between nodes (see figure 1). The use of graphs thwarts criticism that we cannot individuate properties if they all rely on further properties for their identity. If the graph is asymmetric, each property will have a unique set of relations which differentiate it from all others.

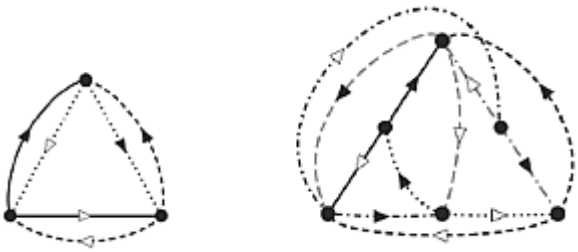


Figure 1 (Bird, 2007, p. 146)

Figure 1 depicts a couple of basic property graphs. The nodes represent properties within Dispositional Essentialism. The arcs represent the relations between the properties. Arrows are used to differentiate between stimuli and manifestations. An arc with an arrow pointing towards a node represents the stimulus of that property. An arc with an arrow pointing away from the node represents the manifestation of the node. The idea is that every property will have a unique stimulus/manifestation structure, so no two properties could be swapped. They each have a unique dispositional essence. This amounts to each property being individuated by a different set of relations (to further properties).

Recall that Bird says that properties *are* dispositions to certain manifestations given certain stimulus. In other words, he says that properties are nothing over and above their stimulus manifestation relations. So, the arcs end up being constitutive of the nodes. It is worth acknowledging that some philosophers do not define dispositions this way (Vetter, 2015; Heil, 2017). They see properties as dispositions to certain manifestations, placing less emphasis on stimulus conditions. However, the key point remains. *In Dispositional Essentialism the identity or essence of properties is entirely given by the relations that they enter into.*

The idea that properties get their essence and identity from their relations raises issues for Dispositional Essentialism. First, it challenges the idea that properties are fundamental and not laws. Dispositional essentialists want to say that the relata (properties) are fundamental but not the relations (laws). However, the relata here are entirely relationally constituted. So, we can never have relata without relations. It is not coherent to say that a thing can exist without the thing that constitutes it. In other words, we cannot have a fundamental base of properties without laws. Properties cannot be metaphysically prior to laws because properties cannot exist without laws. And this

goes beyond properties and laws necessarily co-existing. They co-exist because the properties are constituted by the laws.

The second problem concerns the idea that properties give rise to laws. Traditional dispositional essentialists have in mind a particular, asymmetric, kind of relationship between properties and laws. This relationship looks a lot like grounding. Hence, Jaag (2014) forwarded the objection in those terms. According to him the issue stems from the nature of the grounding relationship. Grounding is an asymmetric relation meaning that if one thing grounds a second thing, the second thing cannot in turn ground the first. Grounding is not circular. What happens if properties ground laws? If properties ground laws, and properties are constituted by laws, circularity ensues. This is because the very thing that grounds laws, is constituted by those same laws. Another reason why grounding looks irreflexive is that grounded entities are meant to be derivative, so they are less fundamental than their grounds. If properties ground laws, laws are less fundamental or derived from properties. Then it is not clear how properties can be constituted by those derivative laws.

The idea that properties are constituted by the laws they give rise to is a massive problem for Dispositional Essentialism. One issue is that the circularity negates the grounding (or asymmetric dependence) claim, making traditional Dispositional Essentialism untenable. Other philosophers – like Stephen Barker (2013) and Siegfried Jaag (2014) - question whether Dispositional Essentialism can explain modality at all given this state of affairs. However, there is another way to get Dispositional Essentialism out of this pickle. In particular, we can argue that properties and laws symmetrically depend on each other (Ibid; Yates, 2018). Asymmetry may be written into the notion of grounding, but it is not written into the notion of ontological dependence. The option of symmetric dependence remains open and, as we saw, there are good motivations for it.

David Yates (2018) picks up on these issues for Dispositional Essentialism. He points out that choosing to give ontological priority to properties or laws puts us in a chicken and egg scenario. Which comes first? The property or the law? The chicken or the egg? Taking the relations to be prior raises the issue of what they are relations of. Taking the properties to be prior clashes with the view that they are relationally individuated which is key to dispositionalism. According to Yates a "no-priority view is clearly

preferable here" (2018, section 4). In his view, symmetric dependence best makes sense of the situation:

> "Symmetric grounding [read 'symmetric dependence'] is a promising way of making sense of relational individuation, and should be seen as a cornerstone of structuralist ontologies in general, rather than an additional commitment of the particular ontology I have defended here." (Ibid)

Here structuralism is used broadly to refer to all views where there is relational individuation i.e. where things are individuated purely based on their relations to further things. Thus defined, Dispositional Essentialism is definitely a form of structuralism. Yates' view is that symmetric dependence not only ought to be accepted within structuralist views but ought not be seen as an additional commitment to a structuralist view. In other words, he sees symmetric dependence as built into structuralism. I take this natural segue into the discussion of properties and laws within Ontic Structural Realism. Showing that there is good reason to think that properties and laws are symmetrically dependent within Ontic Structural Realism (as well as Dispositional Essentialism) lays the foundation for my hybrid view.

7.5.4.2 Ontic Structural Realism

I ended the previous subsection with Yates' claim that structuralism and symmetric dependence go hand in hand. This is because, within structuralism, objects are relationally individuated. As such, they rely on their relations for their identity and vice versa. The idea that relations depend on relata may not sound new. We expect relations to depend on their relata in the way "being 5 metres apart from" depends on the things which are 5 meters apart from each other. However, the relation "being 5 meters apart from" and the things which bear that relation do not depend on each other for their identity. Many different relata could fulfil this relation, and then cease to fulfil it. Neither the relation nor the relata would have fundamentally changed. This is not what is meant by relational individuation. Within structuralism relata have no content, identity or existence beyond their relations and vice versa.

We looked at relational individuation and symmetric dependence in Dispositional Essentialism. On this view, properties are nothing over and above their dispositions to certain manifestations or, in other words, their relations to further properties. For

instance, charge is nothing more than its disposition to repel like charges and attract opposite charges at a certain rate. Here I will consider relational individuation and symmetric dependence in the context of Ontic Structural Realism. I will start by looking at Esfeld and Lam's (2011) incorporation of symmetric dependence into the view. They argue that *objects and properties* are symmetrically dependent. I lay this out as a precedent and example of taking symmetric dependence into Ontic Structural Realism. However, contra Esfeld and Lam, my interest is not in objects (I remain neutral on the status of objects in this thesis). Thus, after laying out the precedent, I turn my attention to my object of study: modality. I argue that we ought to view properties and laws as symmetrically dependent within Ontic Structural Realism.

Current science is hostile to traditional objects, which are discernible and have separate properties (for more details see section 6.2.1). This has led to revisionary views of objects. On the farthest end of the spectrum we have ontic structural realists like Ladyman and Ross who claim that there are no objects, structure is all there is (2007). However, their ontology is unclear. At times it appears that they only posit abstract structure but have yet to account for what is concretely instantiated in our world. I have focused on French (2014), Esfeld (2004, 2009) and Esfeld and Lam (2011), as French is a leading figure of the movement, and these philosophers are highly metaphysically engaged. They aim to shed light on the ontological underpinnings of the views, showing how exactly "structure" – a slippery term - can give rise to reality as we know it.

What French, Esfeld and Lam can all agree on is that there is no room for traditional objects in our ontology. They also agree that the distinction between objects and properties is conceptual rather than ontological (French, 2010; Esfeld and Lam 2011). However, they do this within different frameworks. French is eliminative about objects. He proposes that we do away with them altogether, having only determinable laws and determinate properties (their instantiations) in our fundamental ontology. Esfeld and Lam, on the other hand, accept objects in a qualified sense.

Esfeld and Lam (2011) make the link between structuralism, relational individuation and symmetric dependence that Yates alludes to (2018). Recall that Ontic Structural Realism is the view that only structure exists. Structure can mean different things depending on the context. It can mean mathematical structure, abstract structure and concrete structure for instance. Esfeld is clear to define structure in terms of properties. Esfeld says that "Structures are properties, too, in a broad sense of the notion of

properties, namely relations instead of intrinsic properties, requiring more than one object in order to be instantiated." (2009, p. 184)

The idea that structure is relational fits with the critique of structuralism given before. In mathematical structuralism or dispositionalism, the things in question (numbers or properties) are identified by their place in the structure i.e. by their relations to further numbers/properties. This is where the notion of relational individuation comes in. On these views, what is distinctive about the object of study is how it relates to its peers, or its place in a wider structure, there is no transcendent individuation to be had. This is how Esfeld and Lam (2011) view objects.

Traditional metaphysics takes objects to be prior to properties or relations. Esfeld and Lam reject this. However, they do not go as far as other ontic structural realists who take the relations to be prior to the objects. Esfeld and Lam see objects and relations as equally fundamental and symmetrically dependent. For Esfeld structures are properties, more specially relations. And, these relations require more than one object to exist to be instantiated (2011). This is because relations are, necessarily, relations between things. We cannot have relations without things which relate.

Not only do relations (here properties) need relata (objects), but the reverse holds too. Given Esfeld and Lam's wider scientific and metaphysical commitments they cannot prioritise objects over relations. To do so would require the objects to be primitively or transcendently individuated. As we saw, quantum objects are not discernible from each other. Further, they are often entangled making their independence and separability questionable. In their view, there is no transcendent individuality of objects. Nothing differentiates one object from another (2011, p. 152). They accept a numerical plurality of objects but that is about it. This lands objects in an interesting position. They are no more than nodes in a structure of relations. "Objects are ontologically dependent upon relations because they don't have any intrinsic properties, so primitive modal relations are the only natures they get to have" (Yates, 2018, p. 22). Esfeld and Lam see properties and objects as mutually dependent. Properties are ways objects are, objects are the things that are the ways (that bear the properties).

In sum: Yates (2018) claimed that structuralist ontologies are naturally committed to symmetric dependence. This is because structuralist ontologies share a common feature: relational individuation. This is seen in mathematical structuralism, where numbers

are individuated by their relations to other numbers. In Dispositional Essentialism properties are individuated by their relations to further properties. Esfeld and Lam (2011) argued that in Ontic Structural Realism objects are symmetrically dependent on the relations they enter into too. However, my focus in this thesis is not on objects. As I move between Dispositional Essentialism and Ontic Structural Realism, I remain neutral on how to conceptualise objects. Instead, my focus has been on modality. In particular, I have focused on properties and laws. In my view, these two follow the same pattern of relational individuation and, as such, ought to be viewed as symmetrically dependent within Ontic Structural Realism.

In order to simplify our discussion of properties and laws within Ontic Structural Realism, I set Esfeld and Lam (2011) aside for now. I return to French's work as it isolates the topic of properties and laws. French sees Ontic Structural Realism as a reverse-engineering of Dispositional Essentialism. For French determinables – or laws/symmetries - are fundamental (2014, p. 290). Determinates or properties are referred to as "dependent" upon the laws (ibid, p. 264) or metaphysical by-products of the laws and symmetries (p. 285). Of course, as we saw, he also says that the fundamental basis of the world cannot be fully determinable, so that there are determinates in his fundamental base (p. 290). However, I set this tension aside for the time being.

In section 7.3 I revised Ontic Structural Realism so that there were also determinable properties and determinate laws in the ontology. This is because, I argued, that determinable laws are relations between determinable properties. Determinate properties instantiate determinate laws. This section will argue that the properties and laws should be viewed as symmetrically dependent. I have in mind that determinable laws are symmetrically dependent on determinable properties, and determinate properties are symmetrically dependent on determinate laws. My argument for this dependence will help shed light on why we need determinable properties and determinate laws in addition to determinable laws and determinate properties.

My proposal is that we move from determinable laws grounding determinable properties, to these two being symmetrically dependent. The root of this argument stems from the very nature of laws. First, we must ask ourselves what French means by laws. In particular, does he mean completely abstract mathematical relations or ordinary laws of nature? When he talks about laws, he references laws like conservation laws,

Newton's laws and Coulomb's law (2014, chapter 9). Thus, I take it that by laws he means the same thing as the dispositional essentialist: laws of nature or scientific laws.

French wants to fundamentalise ordinary laws of nature – or scientific laws. In chapter 2 we saw that these are functional or determinable laws. So far so good. Where I diverge from French is with regards to his simple picture of modality where determinable laws give rise to determinate properties. In my view, fundamental determinable laws require fundamental determinable properties. After all, laws of nature like Coulomb's law, the law of gravitation, the law of thermodynamics, and even the symmetries French mentions separately, all share a common feature. The laws all relate determinable properties.

Coulomb's law relates the determinable properties of charge and distance to give us a general recipe for how charged objects interact. Newton's law of gravitation relates the determinables of mass and distance to give us a general equation outlining how objects attract each other. This is the recipe of a law of nature, it relates determinable properties to give a determinable insight into their behaviour – an equation that we can apply to know how an object of any magnitude of the determinable in question will behave.

If French's determinable laws are relations between properties, then their existence requires the existence of the properties they relate. Let's assume that Coulomb's law is a real law, that it captures the relations between real properties and will not be overturned in future. If "charge" and "distance" did not exist it is not clear how Coulomb's law, as a relation between these quantities, could exist. Further, these properties rigidly designate the law. Coulomb's law could not simply hold between any properties. In structuralism, the laws are almost internal to the properties because the properties have unique relational essences which the laws codify. Further, it is worth noting here that the determinable law requires the existence of the *determinable* property. Coulomb's law is about "charge" not about a collection of charges. After all, within French's framework the only way to account for modality is from the top – from the generality – down. He would not allow bottom-up explanations of determinables in terms of collections of determinates. He believes that the collection of cases cannot adequately ground the high-level modal regularity (2014, p. 247). Indeed, this is at the core of his rejection of Dispositional Essentialism.

At the same time, the existence of determinable properties will depend on that of determinable laws – hence we have symmetric dependence. This is because, in keeping with ontic structural realist ideals, French cannot resort to Categoricalism or transcendent individuation for his properties. Properties have no essence or existence beyond their relations. Such is the nature of structuralism. Properties cannot get any identity if not from relations, so they depend on laws.

I have shown that within Ontic Structural Realism determinable laws require determinable properties and vice-versa. I will not give a detailed explanation for why the same will hold of determinate properties and determinate laws because it repeats what has been said before. Determinate properties are what they are in virtue of their place in a structure. There is no transcendent individuation. Thus, determinate properties will be individuated relationally (via determinate laws). Determinate laws are relations between determinate properties. Thus, determinate laws can only exist and be legitimate if the determinate properties they relate exist.

7.6 The hybrid, detailing the view and tying up loose ends

In this chapter I have argued for a number of changes to Dispositional Essentialism and Ontic Structural Realism which I say constitute a hybrid view. In particular, I argued that their modal ontologies of determinate properties and determinable laws were incomplete. I also argued that the idea that laws asymmetrically depend on properties or vice versa does not work. I argued for a hybrid view by showing that properties and laws depend on each other for their identity and existence. In my view, both are equifundamental and mutually dependent. In this section I will recap some of these arguments, elaborating on my view and why it is a hybrid view between Dispositional Essentialism and Ontic Structural Realism.

I will start by sketching a hybrid view between Standard Dispositional Essentialism (figure 3) and Ordinary Ontic Structural Realism (figure 7). This view involves a symmetric dependence between determinate properties and determinable laws (see figure 10). This allows me to recap some of my arguments from 7.1 and 7.2 in justifying why I do not go for this obvious kind of hybrid view on the basis that it is incomplete. After, I will sketch my hybrid view. In my view determinate properties symmetrically

depend on determinate laws, and determinable properties symmetrically depend on determinable laws (figure 11). I will explain why I take this view to be a hybrid between Dispositional Essentialism and Ontic Structural Realism. I will also clarify its status regarding objects. It is neutral on objects - compatible with anything from traditional views to radical eliminativist views of objects.

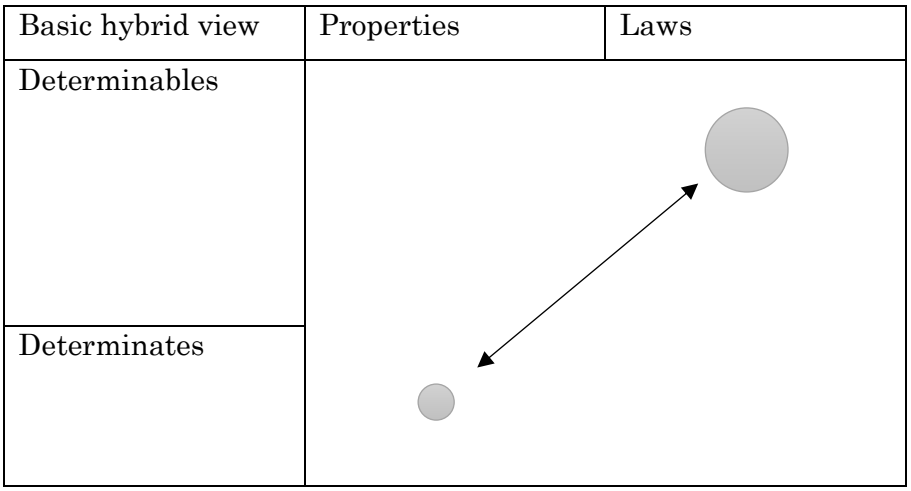


Figure 10. This depicts the overlap, or merger, between Standard Dispositional Essentialism's modal ontology and Ordinary Ontic Structural Realism's (figures 3 and 7). Without further argumentation, it could look like what I mean by a hybrid view.

Talk of a hybrid view between Dispositional Essentialism and Ontic Structural Realism could bring figure 10 to mind. Figure 10 is what you would get if you superimposed figure 3 (Standard Dispositional Essentialism) and figure 7 (Ordinary Ontic Structural Realism). Standard Dispositional Essentialism takes determinable laws to ontologically depend on determinate properties. Ordinary Ontic Structural Realism takes determinate properties to ontologically depend on determinable laws. Thus, it could seem like a hybrid view would have determinate properties and determinable laws symmetrically depend on each other.

The basic hybrid view (figure 10) is not my hybrid view. It is incomplete because the views it is a hybrid of - Standard Dispositional Essentialism and Ordinary Ontic Structural Realism – are incomplete. These views use two categories to explain modality: determinate properties and determinable laws. I argued that these do not suffice.

In 7.2 I looked at the problem from Dispositional Essentialism's point of view. Dispositional properties naturally generate laws within this view. However, determinate properties cannot generate the determinable laws. I argued that determinable properties were necessary to explain determinable laws, on the basis that determinable laws are relations between determinable – not determinate – properties. Determinate properties simply cannot fulfil this role. That said, determinate properties will still be modal/dispositional and generate the corresponding determinate laws. This is because the lawlike relations are internal to the properties at hand.

In section 7.3 we saw that this holds of Ontic Structural Realism as well. Determinable laws seem to require determinable properties. This is because determinable laws are relations between these determinable properties. At the same time, we will need determinate laws. This is because determinate properties almost trivially, or by definition, instantiate determinate laws. What makes a determinate property what it is is its structural or relational profile, that profile is the determinate law. Again, we cannot have a property without a corresponding law. This set the scene for the previous section where I argued that properties and laws are symmetrically dependent.

In 7.5 I argued that both Dispositional Essentialism and Ontic Structural Realism are inadequate. They differ over whether properties or laws come first, and over which explains which. However, as we have seen, for every property there is a law and for every law there is a property. I argued that these ought to be viewed as equally fundamental and symmetrically dependent. This is because properties get their identity from their relations to further properties or, in other words, the laws they partake in. At the same time, laws are relations between properties and so they get their identity and existence from the properties in question. Properties and laws depend on each other for their identity and existence. Asking which came first is like asking "Which came first? The chicken or the egg?" Hence, my hybrid view is the one depicted in the following figure – figure 11.

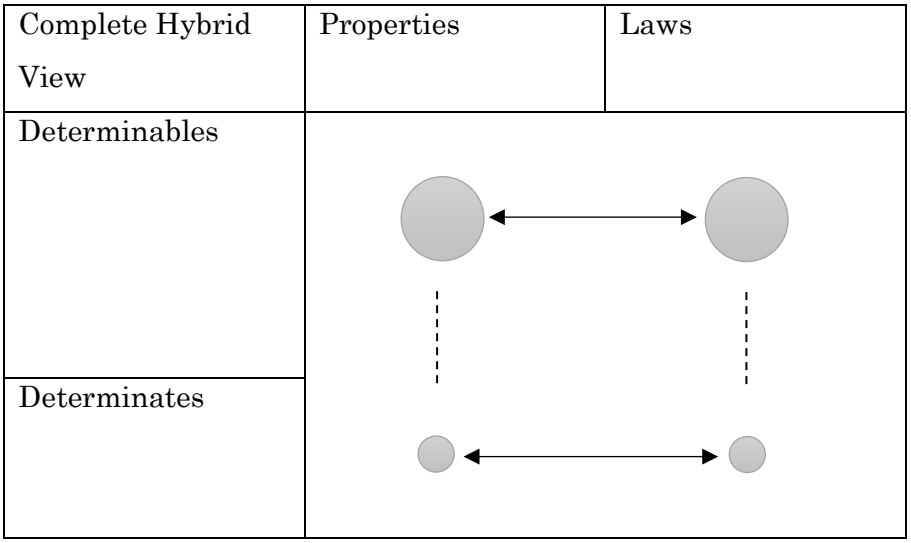


Figure 11 depicts my hybrid view. Determinable properties and laws are symmetrically dependent, as well as determinate properties and laws. The traced line represents the relationship between determinates and determinables.

Figure 11 depicts my hybrid view. Determinate properties and determinate laws are symmetrically dependent. They are also equifundamental because one cannot be deemed prior to the other. Determinable properties and determinable laws symmetrically depend too. They are equifundamental because one cannot be deemed prior to the other. The relations of symmetric dependence are depicted by the two-way arrows.

The traced lines represent the relationship between the determinable and determinate levels, discussed in section 7.4. I did not attempt to work out all details of the relationship here. Rather, I highlighted the ways in which they are related and, more importantly, the ways in which they are *not* related. On the one hand, determinates under the same determinable resemble each other in a way they cannot resemble other determinates. Further, they are determinates or instantiations of determinables. However, I argued that this relationship is not one of ontological priority or relative fundamentality. We cannot metaphysically explain the determinate level via the determinable level or vice versa. We cannot say that one level is ontologically dependent on the other, or eliminate one level from our fundamental base, without leaving something out.

My symmetric dependence view can be seen either as a rejection or a merger of Dispositional Essentialism and Ontic Structural Realism. Dispositional Essentialism takes laws to depend on properties. Ontic Structural Realism takes properties to depend

on laws. In a sense I reject both claims. I reject them insofar as the dependence is meant to be asymmetric. I have shown that it is extremely difficult to establish ontological priority among properties and laws. Properties and laws depend on each other for their identity and existence.

Esfeld and Lam (2011, p. 150) claim that objects and properties can only be separated in thought not reality. Similarly, I claim that properties and laws can only exist separately in thought, not in reality. We cannot have a property be instantiated without a respective law being instantiated and vice versa. Even at the determinable level, for a determinable law to exist its counterpart determinable properties must exist.

My view can be seen as a rejection of Dispositional Essentialism and Ontic Structural Realism. However, I see it as a merger. I take the insights of both views and bring them together. I reject the dispositional essentialist view that properties metaphysically explain or give rise to laws. However, I completely accept that laws depend on properties for their identity and existence. Similarly, I reject French's claim that properties are dependent on laws. I reject it because the dependence only runs one way with properties being ontologically secondary to laws. However, I completely accept that properties depend on laws in a broader sense (without the assumption that that dependence is asymmetric).

In my view Dispositional Essentialism is right to say that laws depend on properties and Ontic Structural Realism is right to say that properties depend on laws. Once we remove the assumption that the dependence is asymmetric, these two claims are compatible with each other. On my view, properties depend on laws and laws depend on properties. Whereas Dispositional Essentialism's dependence arrow goes from laws to the fundamental properties on which they depend, and Ontic Structural Realism's goes from properties to the fundamental laws on which they depend, on the hybrid view the dependence arrow goes both ways (see figure 11). Properties and laws are on equal footing. They are equifundamental and mutually dependent.

As I draw this chapter to a close it is worth restating that my interest has been in modality – properties and laws. As such, my view is a hybrid between Dispositional Essentialism and Ontic Structural Realism with regards to properties and laws. I merge their ontological underpinnings for modality. In that sense the merger is qualified. I have purposefully avoided the discussion of objects for two reasons. One reason is that

settling the issue of how we ought to view objects across these theories is beyond the scope of this thesis. I am partial to the scientific arguments for a rejection of traditional or classical objects, but a positive account of how to view objects in light of these arguments is a topic for another thesis.

The second reason why I have avoided the topic of objects is that I do not see it as important for my view. My hybrid view is consistent with both an acceptance of traditional objects (as is often the case within Dispositional Essentialism), a qualified view of objects (e.g. Esfeld and Lam's (2011)), or a total elimination of objects (as French proposes). These stances are all separate and compatible with the view of modality forwarded in this thesis. After all, the hybrid view is about modality – properties and laws – and does not touch on objects. In fact, I could argue that the hybrid view is an umbrella, opening the way for a spectrum of hybrid views to emerge. In philosophy there are often as many variations of a view as there are philosophers. Here I leave room for a variety of hybrid views depending on the specific stances taken on objects. The core of the view is the symmetric dependence of properties and laws within structuralism.

8. The hybrid view – a summary and why it is the best of both worlds

In the previous chapter I introduced my hybrid view. It is a hybrid between Dispositional Essentialism and Ontic Structural Realism. Dispositional Essentialism takes determinate properties to be fundamental, and determinable laws to be ontologically dependent on them. Ontic Structural Realism reverses the dependence. It takes determinate properties to ontologically depend on determinable laws. I filled out the ontologies of both, to include determinate laws (as well as properties) and determinable properties (as well as laws). I argued that properties and laws symmetrically depend on each other. In particular, I argued that determinate properties and determinate laws are symmetrically dependent, and that determinable properties and determinable laws are symmetrically dependent. My argument was based on the fact that, within structuralism and dispositionalism, properties and laws depend on each other for their identity and existence.

I addressed many of the objections to my hybrid view at the end of the previous chapter. I addressed two major concerns: the causal overdetermination from realism about determinates and determinables (7.4.1-7.4.3) and concerns about symmetric dependence (section 7.5). Additionally, I explained why my view can be said to be a hybrid and how it differs from Esfeld and Lam's symmetric dependence view (section 7.6). In this chapter, I will address a few lingering concerns which have only been briefly acknowledged so far. In section 8.1, I look at the potential worry that my hybrid view will be a bad combination of the previous two views. The worry is that it would be subject to the problems of both views, so it would be the worst of both worlds. Both Dispositional Essentialism and Ontic Structural Realism have unique selling points and shortcomings. I will be arguing that the hybrid view avoids the shortcomings of these views while retaining and superseding the best they have to offer. The hybrid view is the best of both worlds.

In section 8.2 I address a final concern for my view. The concern is that my view is less parsimonious than Dispositional Essentialism and Ontic Structural Realism. This is because my view posits determinate properties, determinate laws, determinable properties and determinable laws. However, Dispositional Essentialism and the French-style Ontic Structural Realism we have looked at only posit determinate properties and

determinable laws. All else equal, more parsimonious explanations are considered preferable, so this is problematic for my view. I respond by saying that all else is *not* equal; the hybrid view has a strong explanatory edge over the other two or a simple combination of both. What the others have in apparent parsimony, they lack in explanation. Further, I argue that this parsimony is only apparent. Properties and laws are flipsides of the same coin. They are entwined such that we cannot really have the one without the other. We cannot have the determinate property without the determinate law, or vice versa. And we cannot have the determinable property without the determinable law, or vice versa.

8.1 The best of both worlds

One potential worry for the hybrid view is that it will absorb the problems of the views it is a hybrid of – it will be the worst of both worlds so to speak. It will not have the explanatory edge Dispositional Essentialism claims over Ontic Structural Realism nor the explanatory edge Ontic Structural Realism claims over Dispositional Essentialism. Both views have unique selling points and there is a risk that merging them into a hybrid view will see those benefits lost. Worse, it might inherit the problems of both the previous views. In what follows I argue that this is not the case. The hybrid view avoids the problems associated with these views. Additionally, it has the explanatory benefits of both views and more. It is the best of both worlds.

I start by surveying the benefits and problems associated with the Bird-style Dispositional Essentialism and French-style Ontic Structural Realism we have looked at in this thesis. As I have already been through these throughout the thesis, my exposition will be brief. I give a summary, highlighting where one view has a problem and how the other view has been said to solve it. This allows me to get to the core of what motivates these views, showing that my hybrid view is a match for them. The hybrid view retains the advantages of the previous two while avoiding the pitfalls associated with them.

8.1.1 Problems for Dispositional Essentialism

The two main relevant problems for Bird-style Dispositional Essentialism are: accounting for natural modality and incoherence in the idea that dispositional

properties give rise to laws. Regarding the first difficulty – accounting for modality – recall that Bird-style Dispositional Essentialism takes determinate properties to be fundamental and account for laws of nature. It is appealing as a way to do away with regularity views of laws which leave modality brute. Rather than leaving modality brute or unexplained, laws are metaphysically explained by the properties. The dispositions of properties generate laws of nature. As we saw in chapter 2, this view faces serious challenges. In its traditional form it fails at doing what it set out to do – account for modality. It is not clear how determinate properties can account for determinable laws. This is because it is not clear how the specific instances could band together to generate the abstract, general law. Rather, we might expect the dependency to run in reverse. Rather than the general law depending on its instances, we might expect the instances to depend on the general law (Wilson, 2012; French, 2014).

The issue accounting for determinable laws stems from the fact that standard (Bird-style) Dispositional Essentialism has determinate properties accounting for determinable laws. The issue is that determinate properties only encode their determinate dispositions. They at best explain determinate laws. Determinate properties cannot explain the dispositions of all other determinates under the same determinable. They cannot explain the determinable law. We can modify Dispositional Essentialism to cope with the issue of accounting for determinable laws. As we saw in chapter 3, if the dispositional essentialist adds determinable properties to her ontology the problem is fixed (Wilson, 2012).

Determinable laws are relations between determinable (not determinate) properties. By adding determinable properties to our fundamental base, we have a plausible explanation for determinable laws. Determinable laws can be explained as ontologically dependent on determinable properties. Within Dispositional Essentialism determinable properties will have dispositions. Those dispositions will give rise to laws. In the case of determinable properties, they will give rise to determinable laws which encode the determinable dispositions. That said, this sort of move has not received much attention in the literature. In the absence of debate about introducing determinable properties, French's presents his Ontic Structural Realism as the way out of this conundrum.

Ontic Structural Realism and Dispositional Essentialism share a project: giving a solid metaphysical account of natural modality. According to French, Dispositional Essentialism's attempt to explain modality fails, but Ontic Structural Realism's

succeeds. Thus, if we want to account for modality within a dispositionalist/structuralist framework we ought to favour Ontic Structural Realism. French solves the issue by inverting the ontological dependence. Rather than explaining the laws as dependent on the properties, he does the reverse. In his Ontic Structural Realism, laws are part of the fundamental base of reality and need no explaining. Rather, the properties are what needs explaining. They are "metaphysical by-products" (2014, p. 285) or "dependent" (ibid, p. 264) on the laws. He avoids the issue of explaining the general law via its instances by explaining the instances via the general law. Ontic Structural Realism is a controversial view but, on this point, it does have an explanatory edge over Dispositional Essentialism.

The second difficulty for Dispositional Essentialism was covered in 7.5.4. Briefly, it is the incoherence with the idea that dispositional properties generate laws. Laws are ontologically dependent on properties for their existence. Yet, the properties in question seem to be entirely constituted by their relations to further properties (laws). Recall that dispositional properties have no categorical basis. They get their essence and identity entirely from their dispositions, or their relations to further properties. This seems incoherent as a thing cannot ground something on which it is dependent (Barker, 2013; Jaag, 2014; Tugby, 2015).

As we saw in chapter 7, grounding is by definition asymmetric, transitive and irreflexive. While dispositional essentialists do not necessarily use that term, there is a presupposition that this is the case with all ontological dependence. It is assumed that if properties ground laws, they cannot be dependent on the laws. However, in the previous chapter I argued against the assumption that dependence is asymmetric. Ontological dependence is an umbrella term for a variety of relations, some of which may be asymmetric. However, the possibility of symmetric dependence is well motivated and becoming well established in the literature (Esfeld, 2009; Thompson, 2016; Barnes, 2018; Yates, 2018).

Ontic Structural Realism does not necessarily come across better than standard Dispositional Essentialism when it comes to the explanation of properties/laws. Dispositional Essentialism suffers from incoherence if it takes laws to be asymmetrically dependent on properties. French's Ontic Structural Realism inverts the dependence. However, inverting the dependence so that relata are asymmetrically dependent on relations raises its own issues. Both views suffer from some level of incoherence because

they rely on relational individuation (see 7.5.4). Briefly, in both Dispositional Essentialism and Ontic Structural Realism relata are individuated purely via their relations to further relata. As such both have difficulty establishing ontological priority between relations and relata.

Views which embrace relational individuation struggle when they try to explain relations via relata or vice versa. Relations require the relata to exist, yet the relata are themselves constituted by the relations. It is hard to say which came first – relations or relata, chicken or egg. As we saw in section 7.5.4, the problem goes away in views where relations and relata are symmetrically dependent (Yates, 2018). This is the motivation for Esfeld and Lam's view (2011) where objects and relations symmetrically depend. It is also the motivation for my hybrid view. My hybrid view, unlike Esfeld and Lam's view, is not concerned with objects. It is neutral on that front (see section 7.6 for a full discussion of how my view differs from Esfeld and Lam's). My view is concerned with modality, allowing properties and laws to be symmetrically dependent on each other.

8.1.2 Problems for Ontic Structural Realism

The main objections for Ontic Structural Realism stem from its revisionist ontology. In particular, it requires a radical reconceptualisation of objects. It also requires a counterintuitive top-down approach to modality. Starting with the issue of objects, every iteration of this view is radically revisionary. In its most radical form, it eliminates objects altogether. Its less radical form takes objects to depend on properties (French, 2010, 2014). Even moderate Ontic Structural Realism is revisionary, seeing objects equifundamental and mutually dependent on properties (Esfeld and Lam, 2011).

The revisionary stance on objects is well justified to the ontic structural realist. After all, their departure point is an aversion to Categoricalism coupled with the work that has gone on in quantum mechanics covered in chapter 6. That said, the idea that objects are prior to their properties, or exist independently in their own right, is one of the most intuitive and widespread of philosophical assumptions. Few philosophers are willing to be deflationist or eliminative about objects. It clashes with how we experience the world, the language we use to describe our experience of the world and hence how we have historically philosophised and ontologised objects. None of this is necessarily damning

for the view of course – our intuitions are often wrong. Further, the ontic structural realist would argue that we have good reason to discard our intuitions here. Nonetheless, the radical revisions Ontic Structural Realism requires keep many philosophers at bay. Let's see how Dispositional Essentialism and my hybrid view fair on this count.

Dispositional Essentialism does not require revisions to our concept of objects. It is primarily a view about properties. In particular, it is the view that dispositional properties account for modality. However, by and large dispositional essentialists appear to have traditional ontologies. They never challenge fundamental objects or engage with the literature on this matter. Further, they generally take properties to be universals (e.g. Mumford, 2004; Bird, 2007) which, again, reinforces the association with a traditional ontology. The fact that Dispositional Essentialism does not require a radical and revisionary ontology on every count is a plus for many (again, that is not to say that they are right or that our intuitions are a guide to truth here).

Similarly, my hybrid view is a view about modality. It is the view that properties and laws are symmetrically dependent. The hybrid view is entirely neutral on the nature of objects. However, this neutrality is more purposeful than the dispositional essentialist's. It takes into account the literature on quantum mechanics that inspires Ontic Structural Realism, allowing for that sort of reading, without committing either way. As noted at the end of the last chapter, the hybrid view can be seen as an umbrella term for multiple hybrid views. This is because the hybrid view of modality can be paired with all sorts of views about objects. There can be versions which are eliminative about objects, traditional about objects, and everything in-between. As such, it can appeal to philosophers all over the dispositionalist and structuralist spectrum.

The other way in which Ontic Structural Realism is revolutionary is in its approach to modality. Many philosophers have properties in their fundamental ontology, with laws being secondary. For categoricalists, laws may be contingent relations between universals or regularities. Our concern has been with Dispositional Essentialism which takes dispositional properties to generate laws. Here modality is explained from the bottom-up - from properties to laws. While not all philosophers agree with the need to explain laws in this way, most agree that properties come first and laws are what needs explaining.

Dispositional Essentialism has a bottom-up approach to modality with laws being ontologically dependent on properties. Ontic Structural Realism reverses this dependence. Properties depend on laws. Some properties may need to be included in the fundamental base (French, 2014, p. 290). However, this is because French sees properties as determinates, so that the properties in the fundamental base represent how the laws happen to be instantiated. French still sees these properties as dependent or as metaphysical by-products of laws (2014, pp. 264–285).

French reverses the intuitive order of things. Where most philosophers take properties to be fundamental and laws to need explaining, he does the reverse. Few philosophers have been willing to take Ontic Structural Realism seriously because it is so radical and counterintuitive. On one hand, this gives Dispositional Essentialism the edge. On the other hand, French can argue that the counterintuitive nature of Ontic Structural Realism cannot and should not be held against it. His view is based on fundamental physics. Fundamental physics is highly counterintuitive. We cannot simply ignore science to save our ontology. If anything, we should be questioning our ontology if it is not compatible with our best science.

As we saw, the hybrid view does not force us to take a stand on objects. It does not force the choice between bottom-up and top-down approaches to modality either. However, that is not to say that it is neutral on modality (as with objects). Rather, properties and laws are on the same level. They mutually depend on each other. The hybrid view does not suffer from the problems the bottom-up approach – Dispositional Essentialism - faced of accounting for modality. The laws are part of the fundamental base. It is compatible with the scientific concerns of Ontic Structural Realism without requiring the unpopular top-down approach to modality. Properties retain their place in the fundamental level without being second-class citizens relative to laws. Additionally, as I argued in the previous chapter, it offers a much more thoughtful framework for understanding properties and laws within dispositionalism/structuralism. Dispositionalism and Structuralism relationally individuate properties and laws. The hybrid view avoids the contradiction between relational individuation and asymmetric dependence by accepting that properties and laws are equals. They are equifundamental and mutually dependent.

8.1.3 Conclusion

Dispositional Essentialism has some persistent problems. It has difficulties accounting for modality. Specific properties are supposed to account for the general laws they obey. Yet the modality of the laws is too broad for an explanation in terms of specific properties. At the same time, Dispositional Essentialism struggles with coherence. It takes properties to be fundamental and to generate laws. Yet, those same properties appear to be constituted by the laws. A thing cannot ground a thing on which it depends. So, we cannot have a grounding-type asymmetric relationship here. Rather, and contra Dispositional Essentialism, we seem to have symmetric dependence. Ontic Structural Realism claims superiority on the modal point. It takes general laws to be fundamental, so they do not need explaining by lower level properties. However, this view has its downsides too.

Ontic Structural Realism suffers from a highly revisionist ontology. It may have very good reasons for this, but the revisions are too much for most philosophers. Extreme versions eliminate objects altogether, moderate versions have objects and properties symmetrically depending on each other. Additionally, Ontic Structural Realism reverses the intuitive order of explanation between properties and laws. How does the hybrid view compare?

My hybrid view is the best of both worlds. By having properties and laws as equifundamental and symmetrically dependent, these problems go away. Regarding modality, it avoids Dispositional Essentialism's difficulty accounting for laws by having them in the fundamental base. At the same time, it does this without making properties second-class citizens as Ontic Structural Realism does.

The hybrid view also avoids the coherence concerns around relational individuation. As we saw, views like Dispositional Essentialism and Ontic Structural Realism use relational individuation. Here relata are individuated by their relations to further relata. This makes it very hard – if not impossible – to justify the primacy of relata over relations (or vice versa). The relata cannot come first because they are relationally individuated. The relations cannot come first because they necessarily hold between relata. The relations are nothing without the relata in question. My hybrid view avoids this problem with relational individuation by allowing relations and relata to depend on each other.

I have shown that the hybrid view avoids the biggest pitfalls of Dispositional Essentialism and Ontic Structural Realism. Clearly it is not the worst of both worlds. At the same time, it does as good if not a better job at meeting the goal of these views – accounting for natural modality. This, to me, makes it the best of both worlds. What is the catch? As we saw in the previous chapter, it has a slightly less sparce ontology and involves symmetric dependence. I defended the use of symmetric dependence in section 7.5. I showed that it is well motivated and makes most sense of the relationship between properties and laws in dispositionalism/structuralism. As for the added categories (determinate laws and determinable properties), I turn my attention to these in the next section where I look at parsimony concerns for the hybrid view.

8.2 Parsimony and explanation

The final objection to my hybrid view is that it is less parsimonious than the alternatives. This can be raised in two ways. First, it is less parsimonious than standard Dispositional Essentialism and French's Ontic Structural Realism. Second, it is less parsimonious than an alternative hybrid view. These other views all account for modality using determinate properties and determinable laws. My view uses determinate properties, determinate laws, determinable properties and determinable laws.

Ockham's razor tells us not to multiply entities beyond necessity. Most philosophers agree that, all else equal, the more parsimonious (the simpler) of two explanations is to be preferred. Here we can distinguish between two kinds of parsimony. An explanation is more quantitively parsimonious if it postulates fewer individual things. Another sense in which an explanation can be parsimonious is if it postulates fewer kinds or types of things; this is called qualitative parsimony. All else equal, the simpler explanation is preferred. However, simple explanations are often worse. So, for instance, ancient philosophers might have believed that the world was made up of identical atoms, or four elements, but the periodic table has 118 elements and standard model particle physics includes 38 distinct elementary particles. The latter do a much better job of explaining reality. Hence, Ockham's razor says don't multiple entities *beyond necessity* or *all else equal* the simpler of two explanations is preferred. What does all else equal actually mean?

Parsimony is one of many theoretical virtues used to evaluate theories (two if you disambiguate between quantitative and qualitative parsimony). Others include evidential accuracy, explanatory depth, internal consistency, universal coherence, unification, durability and fruitfulness (Keas, 2018). Thus, the simplicity (or lack of simplicity) of a theory is just one reason to accept (or reject) that theory. Let's say that we could quantify a theory's theoretical virtue. If two theories seem equally virtuous, parsimony can be used as the deciding factor. Parsimony may sway us one way rather than another. However, all else is rarely equal. It is very hard to measure theoretical virtue. And, even if we could measure it, competing theories score very differently on different virtues. So, one might be very parsimonious but not very unified. Another may have excellent internal consistency but score low on parsimony. Rarely does parsimony prove the deciding factor. Parsimony is desirable, but if a theory has a problem with "evidential accuracy" that probably outweighs the parsimony concern.

The issue for the hybrid view is that Bird-style Dispositional Essentialism and French-style Ontic Structural Realism are more parsimonious than my hybrid view. Standard Dispositional Essentialism takes determinate properties to explain all modality (Bird, 2007; Wilson, 2012; Vetter, 2015). Determinable laws ontologically depend on determinate properties. Ontic Structural Realism takes determinable laws to be fundamental. Determinate properties are fundamental too as they give us non-modal information, differentiating our concrete world from a world where nothing is instantiated. We need determinates to account for the world as we know it, its causal sequences, and concrete goings on. However, we have also seen that they are "metaphysical by-products" of determinable laws (French, 2014). Despite their fundamentality, determinate properties are dependent. They ontologically depend on determinable laws. In both cases, we have determinate properties and determinable laws accounting for modality (as I have said, I am leaving objects out).

Not only are Standard Dispositional Essentialism and Ordinary Ontic Structural Realism more parsimonious, a basic hybrid view between the two would also be more parsimonious than my hybrid view. Let's briefly set aside the arguments for my specific hybrid view set out in the last chapter. If I say that my view is a hybrid between standard Dispositional Essentialism and French's Ontic Structural Realism, and that what makes it a hybrid is the symmetric dependence between properties and laws, figure 10 from the last chapter might readily come to mind:

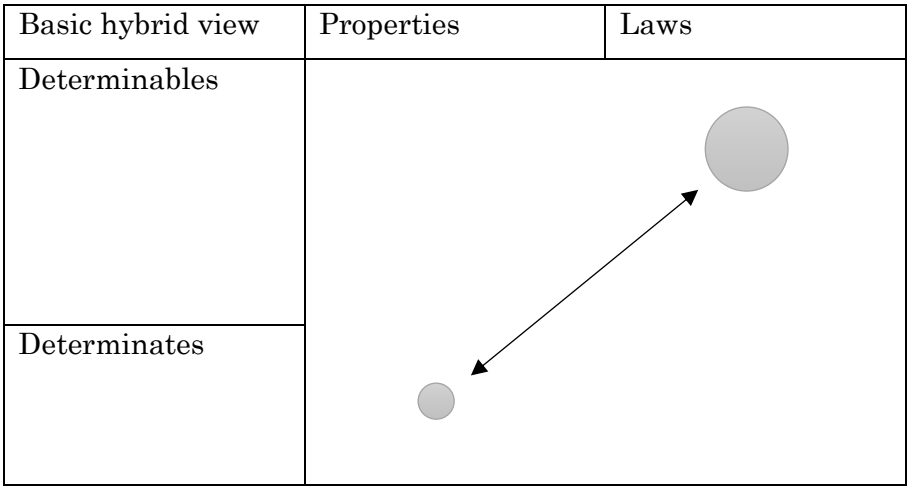


Figure 10. This depicts the overlap, or merger, between Standard Dispositional Essentialism's modal ontology and Ordinary Ontic Structural Realism's (figures 3 and 7).

Figure 10 – Basic Hybrid View – is what you get when you superimpose figures 3 and 7 (Standard Dispositional Essentialism and Ordinary Ontic Structural Realism). The categories – determinate properties and determinable laws – remain the same. The ontological dependence of determinable laws on determinate properties of Dispositional Essentialism is kept. At the same time, the ontological dependence of determinate properties on determinable laws of Ontic Structural Realism is kept. So, the only change is to the ontological dependence arrow. Rather than asymmetrically pointing one way, it points in both directions. This symbolises the symmetric dependence of determinate properties on determinable laws. Yet this is not my hybrid view. My hybrid view is depicted in figure 11.

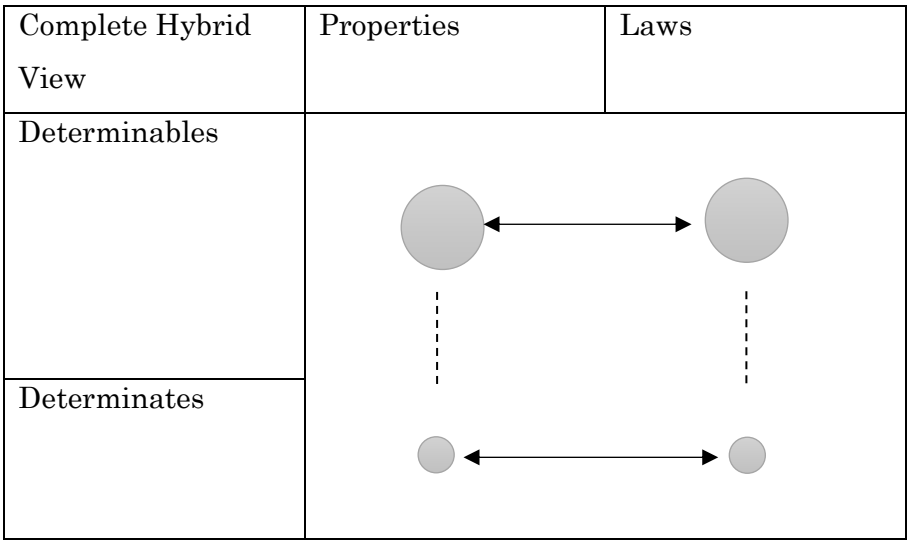


Figure 11 depicts my hybrid view. Determinable properties and laws are symmetrically dependent, as well as determinate properties and

laws. The traced line represents the relationship between determinates and determinables (discussed in 7.4).

In the last chapter I detail and argue for my hybrid view as depicted in Figure 11. However, I did not address the issue of parsimony. My hybrid view is less parsimonious than the Basic Hybrid View. It takes determinable properties and determinable laws to symmetrically depend. It also takes determinate properties and determinate laws to symmetrically depend. This symmetric dependence is represented by the ontological dependence arrow. In addition, the traced lines represent the relationship between the determinable and determinate levels. We know there must be some such relationship, but that relationship will be different from the symmetric dependence relationship (see section 7.6 for more details).

My hybrid view is less parsimonious than the basic hybrid view because it has more categories and it invokes more than one kind of relationship between those categories. I have argued extensively for the need for this added nuance (section 7.2 and 7.3), however I will recap those arguments here to show that lesser parsimony is not a problem for my view. The explanatory benefits of fleshing out the ontology of the other views – Standard Dispositional Essentialism, Ordinary Ontic Structural Realism and Basic Hybrid View - outweigh the negatives. Further, I argue that no radically new kinds of entity are added to my hybrid view to get that that benefit.

Early in this thesis, in particular in chapter 3, we saw that Standard Dispositional Essentialism failed to give an account of determinable laws. I will not go into details here as this problem has been a focus of the thesis, rehashed in sections 7.2 and 8.1. Broadly, we saw that the modality of determinable laws outruns that of determinate properties, so determinate properties cannot account for determinable laws. Without the addition of determinable properties, Dispositional Essentialism fails to deliver on its promise of accounting for all modality. Laws are left brute. The addition of this new category is of such explanatory benefit to Dispositional Essentialism, I would say it is explanatorily necessary in the sense that it is needed to meet the explanatory aims of the theory.

The fact that determinable laws cannot be accounted for via determinate properties is appreciated by French (2014). As we saw, he proposed we fundamentalise determinable laws in order to get around this problem. However, he misses the same point as the

dispositional essentialist here. We still need determinable properties because determinable laws are relations between determinable properties. It is not clear how we can have a rich plethora of different relations (laws) without the things they relate (properties).

When I say that determinable laws are relations between determinable properties, I do not mean that they are relations like the relation of being 6 meters apart from, where any two relata can fulfil that relation. The law of gravitation relates mass and distance in a much more intimate way. From a dispositional or structural perspective, the property of mass is intimately tied to its disposition to manifest a gravitational force. Mass cannot be understood separate from the effects of mass – to exert said force. At the same time, the law of gravitation depends on mass and distance. The idea that the law of gravitation can be prior to mass is bizarre.

The core of the problem for Dispositional Essentialism and Ontic Structural Realism is relational individuation. Dispositionalism and Structuralism relationally individuate properties. Additionally, laws are relations between properties. The natures of properties and laws are entwined as they depend on each other for their identity and existence (Yates, 2018). There can be no determinable law without the determinable properties. These rigidly designate the law. Coulomb's law is a relation between charge and distance. It makes no sense to say that the law exists prior to the properties it relates.

The entwined nature of properties and laws also applies at the determinate level. Determinate properties are relationally individuated in structuralism/dispositionalism. As such, they are nothing more than their relations or their dispositions to their specific manifestations. They are individuated and their existence is dependent on those relations. Those relations are determinate laws. In other words, the relations are the limiting case of the determinable laws which apply to the property in question. We cannot simply individuate determinate properties via determinable laws, as these do not favour any one determinate property over any other determinate property of the same determinable.

My theory may well be less parsimonious than Dispositional Essentialism and Ontic Structural Realism (or a basic hybrid of the two). However, in my view it is very efficient. A small ontological increase allows for great explanatory gains. The increase

seems even more sparse from the perspective that we already had determinates, determinables, properties and laws in the previous views. So, I am not necessarily introducing a completely new kind of thing (which would be a bigger violation of qualitative parsimony). Rather, I am fleshing out the ontology that was already there. From the perspective of a Humean regularity theorist or a philosopher who aims to have the sparsest possible ontology, my view may not seem like an improvement. However, Dispositional Essentialism and Ontic Structuralism have the explicit goal of accounting for modality (Bird, 2007; French, 2014). I have shown that their views fall short of their aims. My hybrid view presents a solution to the problem of accounting for modality. At the same time, the motivation for my view runs deeper than that.

Standard Dispositional Essentialism, French's Ontic Structural Realism, and a "basic" hybrid view leave gaping holes in their ontology. These holes are left by relational individuation. Properties are individuated by their relations. Yet, in Dispositionalism, any relations are ontologically secondary to the properties themselves. At the same time, laws of nature are relations between properties, yet in both views the things they relate (determinable properties) don't exist. This places the very coherence of Dispositional Essentialism and Ontic Structural Realism in question. A very healthy respect for parsimony would not have us choose an incoherent view over a coherent one, with more explanatory power, for the sake of a slightly more austere ontology.

8.3 Conclusion

I dealt with the most pressing objections to my hybrid view at the end of chapter 7. These included the concern over symmetric dependence (section 7.5), how my view can be said to be a hybrid and how it differs from Esfeld and Lam's symmetric dependence view (section 7.6). In this chapter I addressed a couple lingering concerns for the view: that it might have all the problems of Dispositional Essentialism and Ontic Structural Realism and that it is less parsimonious than these views.

Dispositional Essentialism and Ontic Structural Realism suffered from two main ailments. First, they suffered from an incomplete ontology of determinate properties and determinable laws. As we saw, determinable laws require the determinable properties they relate. Similarly, determinate properties require determinate laws for their

identity and existence. The second and related ailment came from a forced choice between placing properties or laws first. Given their entwined nature such a choice comes at the cost of coherence. My hybrid view avoids both these difficulties.

The problems associated with Dispositional Essentialism and Ontic Structural Realism go away once we allow properties to be symmetrically dependent on laws. With determinate properties symmetrically depending on determinate laws, and determinable properties symmetrically depending on determinable laws, the coherence problem goes away and the ontological gaps are filled. The fact that properties and laws depend on each other for their identity and existence is no longer a problem but a natural consequence of the structuralist worldview. This, in my view, outweighs the parsimony concern. Having a slightly less austere ontology is a small price to pay for a coherent ontology that delivers on the promise of accounting for modality.

9. Conclusion

At first glance Dispositional Essentialism and Ontic Structural Realism have little in common. Dispositional Essentialism is a view about properties. It is the view that there are dispositional properties which account for laws of nature. It circulates in the metaphysics literature as the solution to quidditism and humility about properties. Ontic Structural Realism is debated in the philosophy of science literature, taking inspiration from quantum mechanics for massive revisions in our understanding of objects. These two appear to have little in common but look beneath the surface and similarities start to emerge.

I used Bird's (2007) Dispositional Essentialism and French's (2014) Ontic Structuralism as my starting point in this thesis. We saw that both these views aim to explain modality. They do so in remarkably similar ways. Bird's Dispositional Essentialism takes determinate (dispositional) properties to explain laws of nature. Yet laws of nature are determinable. French's Ontic Structural Realism takes determinable laws to be fundamental, and determinate properties to be what needs explaining. The dependence is inverted. This leads French to claim that Ontic Structural Realism is a reverse-engineering of Dispositional Essentialism (2014, p. 264). It also led Chakravartty to differentiate between the two views by saying that Dispositional Essentialism gives a bottom-up explanation of modality whereas Ontic Structural Realism's is top-down (2019).

There are challenges for both views. Dispositional Essentialism has difficulties accounting for laws of nature. It is unclear how we can explain determinable laws via determinate properties, while avoiding any sort of regularity view. The fact that so many determinates obey a single law calls out for explanation. If anything, it looks like the determinable law explains why the determinate properties manifest in the ways that they do. Worse, global principles are particularly hard to give a bottom-up account of. Global principles are high-level laws like symmetry principles, conservation laws and the principle of least action. They apply to a wide range of properties, if not the whole world. As a result, it is hard to see how global principles can be accounted for via the dispositional essences of individual properties. Ontic Structural Realism presents itself as the solution to Dispositional Essentialism's problems. It takes laws (including those troublesome global principles) to be fundamental. Thus, determinable laws need no explaining. They are part of the fundamental fabric of the world.

I argued that we need to add determinable properties to our ontology. Determinable properties help both views make better sense of laws of nature. Within Dispositional Essentialism, determinable properties could be dispositional and so account for determinable laws (Wilson, 2012). As I showed in chapters 4 and 5, the dispositional essentialist can use these to deal with even the most elusive laws: global principles. At the same time, Ontic Structural Realism is problematic if it has fundamental determinable laws but no determinable properties. Laws are relations between properties, so it is not clear what these determinable laws amount to if they have nothing to relate. I make a similar case at the determinate level. Dispositional properties require dispositional laws. So, I argue that each instantiated determinate property will instantiate a determinate law. By adding determinable properties and determinate laws, the first step towards my hybrid view is accomplished.

My hybrid view merges Dispositional Essentialism and Ontic Structural Realism's ontologies with respect to modality. It does this by taking properties and laws to be symmetrically dependent. Properties are individuated by their relationships to further properties. So, it is not clear how they can be metaphysically prior to, or more fundamental than, the very relations which individuate them (the laws of nature). At the same time, laws are relations between properties. So, it is not clear how the relations can exist without relata. My proposal is that properties and laws symmetrically depend. Laws of nature depend on the properties they are about, and the properties depend on the laws which constitute them. Determinable properties and determinable laws symmetrically depend, determinate properties and determinate laws symmetrically depend.

Symmetric dependence is a controversial matter. However, as I argued in chapter 7, there are cases where symmetric dependence is warranted. In my view, there is no clearer example than in the case of properties and laws. Within dispositionalism and structuralism, properties are individuated by their relations to further properties. They get their identity, and their existence depends on, those relations. So, they cannot be prior to those relations. Similarly, laws of nature are the relations between properties. Any theory which requires us to accept that the laws are prior to the properties they are about will be more controversial than mine.

Relational individuation is core to Dispositional Essentialism and Ontic Structural Realism. Most of the problems with their accounts of modality stem from them pairing

this relational individuation with a traditional hierarchy of fundamentality whereby either properties depend on laws, or laws on properties. This has landed both views in a chicken-egg argument. My hybrid view presents a way out of this chicken-egg-property-law dilemma. Further, given how Dispositional Essentialism and Ontic Structural Realism can seem like mirror images of each other, it strikes me as quite bizarre that this avenue has not yet been explored.

My hybrid view brings a fresh perspective on the tensions of dispositionalism and structuralism. It forwards a new way of seeing dispositional properties and laws. At the same time, it is important to stress that this is just a view about modality. It takes inspiration from Dispositional Essentialism's metaphysics of modality and Ontic Structural Realism's metaphysics of modality, fleshing out their ontologies so that they can be merged. The hybrid view is neutral on objects. In that sense it is not a full hybrid of the two views.

The hybrid view is compatible with multiple takes on objects, from traditional objects (usually associated with Dispositional Essentialism), to the revisionary objects of radical Ontic Structural Realism, and everything in between.

I have said before that there are as many Dispositional Essentialisms as there are dispositional essentialists. There are as many Ontic Structural Realisms as there are ontic structural realists. Perhaps my hybrid view is just one more of these voices. However, it has the potential to open the door to a new set of positions where dispositional essentialists and ontic structural realists are no longer pitted against each other. It has the potential to reconcile two fruitful camps of philosophical debate and innovation – Dispositional Essentialism and Ontic Structural Realism – so that they may spend less time arguing with each other and join forces to tackle new problems. Either way, it seems clear to me that these two views are much closer than they seem. They share a structuralist core that has only begun to be explored.

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